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Review Article

Water Systems Strategy Relation with Horticultural Crops

Attia El Gayar

Soil, Water and Environmental Research Institute (SWERI), Agriculture Research Centre (ARC), Giza, Egypt
Corresponding author e-mail: attiaelgayar@yahoo.com
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ABSTRACT
Integrated water management means putting all the pieces together. Social, environmental, and technical aspects must be taken into consideration. Issues of concern include: providing forums; Reshaping planning processes; Coordination of land and water resources management; Identify the links between water sources and water quality; Develop protocols for integrated watershed management; Addressing institutional challenges; Protecting and restoring natural systems; Reformulation of existing projects; Knowing the views of society; Clarify education and communication risks; Technology standardization and policy; Form partnerships and emphasize preventive measures. The highest priority for water resource management is to increase the demand for water with limited water resources. Water resources are the foundation for sustainable development, so a sustainable approach must be based on the use and management of water resources. In the twenty-first century, the world faces a major water crisis. The problems stem from errors in the management of water resources. Consequently, the sustainable use of water resources is crucial for humanity. Sustainable development is defined as the goals of supply and today's needs without jeopardizing the goals and requirements of future generations. Long-term goals should be considered instead of short-term goals in assessing water resources. This approach forms the idea of integrated water resource management for horticultural crops. This paper describes the evolution of water use in relation to productivity, how irrigation systems have developed and managed, and a strategy to explore challenges and opportunities for water conservation in horticulture crops.
Keywords: *Water Resources Management, Sustainability, Horticultural Crops, Integrated Management strategy.*

INTRODUCTION
The sustainable management of water resources is very important for the ecosystem in terms of providing the basis for sustainable development because water resources are a vital issue for humans. Building sustainable management and certification awareness is also important in water resource engineering. The integration of the environment with all its natural resources and its commitment to achieving all improvement plans in the philosophy of sustainable development results from the necessity of integrated management of water resources. And because agriculture always involves economic risks, humankind has long sought ways to reduce the weather risks that affect agriculture. Even in early civilizations, farmers noted that complementary application of water to land could reduce the effects of drought. The basic tenants of irrigation have been understood at least since the time of the Sumerian civilization more than 6000 years ago: one needs to get water on Earth, keep it there as long as it is needed, get rid of it when it is no longer required, and keep unwanted water out (Ryan and Pitman, 1998). However, it took several centuries of irrigation for humanity to realize that irrigation could have negative environmental consequences, mainly from salt build-up, and that irrigation practices must be managed to control salt (Gardner, 1993; van Schilfgaarde et al., 1974). Such negative impacts combined with indirect negative societal impacts due to agricultural water diversion, now pose a threat to the future of irrigation that must be appropriately addressed if irrigated gardening is to be a sustainable management system.

The increasing demand for water for other uses in our society coupled with water scarcity leads to unprecedented pressure to reduce the share of freshwater used in irrigation. Until recently, the community had responded to the increasing demand for water by developing new supplies. This is no longer possible in many cases today, as the economic and environmental costs of new developments in water

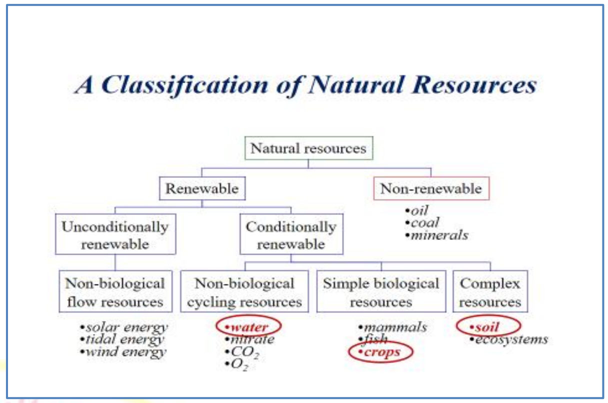
sources exceed the perceived benefits. The alternative to new development is to conserve existing resources. Therefore, agriculture, as the primary user of the diversed water, is subject to careful scrutiny. Water for agricultural use is the first to be considered a new source of supplies for other uses, especially in situations of scarcity. Indeed, the reallocation of water from agriculture to other sectors has already begun in many areas and is expected to increase in the future. While agriculture is required to give up water, the world's growing population requires agriculture to increase food production. By 2025, the world will need 40% more grains (IFPRI, 1999) and is also turning towards increased consumption of fruits and vegetables. This conflict will not be resolved in the coming years unless we are able to meet the challenge of increasing crop yields per unit of water consumed, especially in irrigated horticulture, a sector in which water has been used generously until recently.

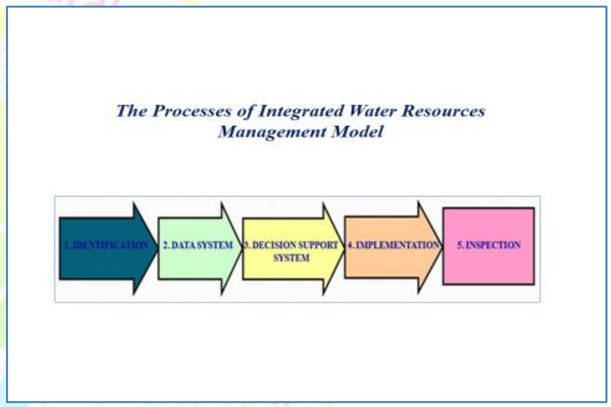
Integrated Water Resources Management

The principles of integrated management to solve the global water crisis come to the fore given the developments that have taken place in recent years. The EU Water Framework Directive, which was implemented in 2000, developed water policies with a watershed-based management approach, protecting them from water resources and controlling them in terms of quantity and quality. With regard to sustainable management policy, the social, environmental, economic, technical and institutional phenomenon as a whole must be dealt with. Integrated water resources management relies on fair and efficient management and sustainable water use.

Integration of environmental media is provided by integrating social, economic, political, institutional, technical, and legal factors with environmental factors (sustainability), specialization integration, integration of actors (coordination), and integration of financial resources, integration of management tools, climate change and risks in integrated water resources management. The integrated management model should consist of the identification stages, the data system, the decision support system, implementation, inspection, and discussion of the stages respectively.

Water demand stakeholders must provide a participatory business approach while practicing all phases. The dispersal of water resources by field of use must be taken into account in integrated water resources management for stakeholder analysis. Water famine, water pollution and water management issues are obligated to deal with watersheds through integrated water resources management in all water resources. The integration of the environment with all its natural resources and the commitment to achieving all plans for improvement in the philosophy of sustainable development leads to the necessity of integrated management of water resources. The protection of water resources and their provision for sustainable use can only be achieved through an integrated management system.





There is a need to improve coordination and cooperation between water resource planning and management agencies. Planning and management contexts must be consistent with the issues they address, and they should recognize relevant ecosystem interactions. Objective forums are needed to address the true dimensions of water management problems, bring stakeholders to the table, and reach consensus. Integrated water management plans should lead decision-making processes over water resources and serve as a basis for developing regulatory programs. Educators play an important role in developing and implementing integrated water management strategies. Teaching, research and service jobs in universities are ideally suited to educating a diverse audience on water management issues. Water management policies must take global dimensions. Coordination, cooperation and cooperation between intergovernmental agencies must be improved. Political processes must be better understood and shaped to focus on holistic approaches to land and water management. Preventive measures must be emphasized, rather than remedial measures.

Water Efficiency in Horticulture

Water used for irrigation is consumed by evaporation from crop or soil surfaces and may also be lost due to runoff or deep filtration. In many cases, these water losses inside the basin can be recovered and reused, albeit with some deterioration in quality. Conservation of water aims to increase the efficiency of irrigation by changing the irrigation method, for example, it may not result in net savings in water if the preserved losses are reversible (Seckler, 1996). Water productivity (WP) is defined as the yield-to-evaporation ratio (ET) (Seckler, 1996). In contrast to efficiency improvements, improving WP by increasing yields and / or reducing ET results in net savings, thereby reducing agricultural water requirements.

Water productivity in irrigated agriculture varies greatly and depends on many biophysical and administrative factors. Since the differences in ET between crops are in order of size, the most important factor affecting white phosphorus is the economic value of the product. Gardening products are usually of high value and therefore white phosphorus usually exceeds field crop products. By using the current crop values and ET properties for California cultivation, the white phosphorus size for corn is about $ 0.20 / m3, compared to $ 0.70 / m3 for almonds, $ 5.00 / m3 for strawberries, and even more for greenhouse crops and ornamental decorations. . An extreme example is vegetable crops grown under plastic in southeastern Spain during the recession. The combination of high market prices and low ET leads to a WP of about $ 10 / m3. While impressive, even this value cannot compete with the value of industrial and urban uses. However, it helps explain the trend of shifting irrigated areas from low-value crops and raw crops to horticultural crops in many water-scarce regions of the United States, a trend that is likely to increase worldwide (National Research Council, 1996).

Historical Perspectives

The history of irrigation parallels that of agriculture itself, as early agricultural developments occurred in the Fertile Crescent in an arid environment. Janick (1979) reviewed the history of irrigated gardening until about the beginning of the twentieth century, when ASHS was created. After 1900, irrigation development accelerated in the United States as population growth increased food production and this pattern repeated on a global basis for most of the twentieth century (Howell, 2001). During the last two decades of the century, the irrigated area in the United States remained relatively stable at about 20 million hectares despite regional differences and some expansion in the mid-1990s (Howell, 2001). Irrigated land currently accounts for 18% of all crops, but about 50% of all crops (Howell, 2001). This high productivity of irrigated agriculture, coupled with changing feeding patterns driven in part by the inclusion of fruits and vegetables as essential components of a healthy diet, led to today's situation where Two-thirds of the vegetables and three-quarters of the fruit produced in the United States is harvested from irrigated areas.

The Semi Arid Zone

Not surprisingly, irrigation development in the U.S. started in a semi-dry region, where very limited precipitation made irrigation necessary for viable agricultural development. There is evidence of widespread irrigation in the Salt River Valley in Arizona and other arid regions (Jensen, 1982).

The Spaniards brought irrigation to New Mexico in the 16th century, and the residents of their expeditions in California developed irrigated lands after the 17th century. Modern irrigation development took place during the nineteenth century and by 1870, there were over 60,000 acres of irrigated horticultural crops on the plains around Los Angeles alone (Hundley, 1992).

By the end of the century, there were about 1.5 million acres of irrigated land in California with nearly two thirds of them devoted to horticultural crops (Hundley, 1992). A number of institutional developments, including the formation of organized irrigation areas, helped boost irrigation growth, with the irrigated land in California expanding to 4.5 million acres by 1930, about 50% of today's area (Hundley, 1992). After that, the expansion of irrigation development slowed to the end of World War II. At that time, the total irrigated area in the 17 western states was about 20 million acres, which more than doubled in the next 30 years to 43 million acres (Jensen, 1982). Irrigation also expanded significantly in the rest of the United States after 1950, moving from one million to seven million acres in 1978 (Jensen, 1982).

The results of Veihmeyer, 1927, 1972, were strongly influenced by the nature of the soil on which he worked with high soil water storage capacity and almost unlimited depth. He noted that others have verified that tree crops can extract 300 to 400 mm of water from these types of soil without causing significant stresses on tree water (Fereres and Goldhamer, 1990; Veihmeyer used manual soil sampling to calculate rates of use Horticultural consumer, and AH Hendrickson, a fellow from the Pomology Department at the University of California, Davis, developed guidelines for irrigation management for most tree crops in California (Hendrickson and Veihmeyer, 1951.) Veyhmeyer has shown in later studies that irrigation can be delayed until depletion.The main part of the root zone to the point of permanent wilt without loss in yield. His previous work showed that a large extraction of water can occur to a soil depth of 3.6 m (Veihmeyer, 1927).

And this level of water supply should be sufficient under horticultural conditions that It was present during those times, including trees with wide distances, to avoid negative impacts on yields with non-recurrent irrigation that resulted in very dry soil in the greater part of the root zone. It would take decades (Uriu and Magness, 1967) until the water dynamics in the soil's atmosphere system were understood.

The Humid Zone

Many wet states in the southeastern United States have rainfall in excess of 1,200 mm / year. Citrus and many other crops were successfully cultivated in Florida without irrigation. If the annual rains match or exceed the seasonal season, Savage (1953) stated that citrus irrigation was not economical in Florida. Koo's later work (1963) and others showed that irrigation increased yields enough to make it worth the investment. The main reasons irrigation can be beneficial in wet southeast areas include soils, rainfall variability, and changes in irrigation technology.

From Carolina through Georgia and Florida, the coastal plain has large areas of sandy soil with low water retention capacity. The water content in the field capacity of some Florida citrus soils can be as low as 6%, and the available water can be as low as 0.049 cm 3. These soils do not have the temporary storage capacity needed to handle short droughts and irrigation becomes necessary to improve yields. . Koo (1963) noted that the precipitation ranged from 836 to 1758 mm in two consecutive years. Several El Niño events caused record rains in December in Florida. This is usually a dry month. There were also periodic droughts in the southeast. In addition to limiting crop yields, these droughts have resulted in forest fires, with consequent environmental damage. In addition to the annual variance, precipitation can be quite localized in place and time and not necessarily come when needed. In some parts of the southeast, rainfall patterns produce very clear dry and wet periods, as in Florida, where more than 60% of precipitation falls between June and September. The flower and fruit group are critical periods of citrus and many other crops, and occur during the Florida dry season. Lack of rain or insufficient irrigation during these periods can significantly reduce yields.

When Savage (1953) concluded that irrigation was not economically feasible, the predominant irrigation methods were floods (in coastal and flat timber groves), top sprinkler, portable perforated pipe, and hexagon sized. During dry periods, sprinklers usually worked every 10 to 14 days, and farmers often delay starting watering for several days, in the hope that rain will eliminate this need. Thus, irrigation was not always applied in time. Water stress developed and fruit yields decreased. Ko (1963) showed that irrigation can be economical for citrus fruits, even in years when the rainfall has increased. By maintaining soil moisture above the drain of a third of the available water from January to June and exhausting two-thirds for the rest of the year, yields increased irrigated controls.

Micro-sprinkler irrigation was introduced to Florida from South Africa in the early 1970s. When it was found that these systems provided some frost protection for citrus fruits (Parsons et al., 1982), small sprinklers were installed on thousands of hectares of citrus in Florida. Florida became one of the fastest growing small irrigation markets in the United States during the 1980s. Most Florida citrus areas are now irrigated with small sprinklers due to the dual advantage of high-frequency irrigation as well as frost protection. Smajstrla et al. (1995) estimate that in 1994, about 20% of the total micro irrigated area in the U.S. were in Florida fruit crops.

Irrigation Processing In Horticultural Crops

Consumptive Use Requirements

Theoretical and experimental research on evaporation from confined surfaces yielded several methods for calculating ET, which is the primary input for determining the amount of water to be applied. Standard procedures for an ET account were successfully developed by Dorenboos and Pruitt (1974) but were recently modified by Allen et al. (1998) and ASCE. All methods are based on the calculation of the reference ET multiplied by the experimentally determined crop factor (Kc) that includes specific features for each crop. At present, there are good estimates of Kc values for most horticultural crops, although most Kc research has been conducted on major field crops (Allen et al., 1998). One exception is the lack of sufficient information on the water requirements of an orchard for young trees. The relationship between ET and terrestrial shaded area, developed for small almond trees (Fereres and Goldhamer, 1990) was used successfully for deciduous and other green fruit trees to adjust a mature ET orchard with those in a canopy of a growing tree. Although piloted, the accuracy of ET estimates is sufficient for most management applications, although there are more mechanical models based on evaporation theory (Monteth, 1965).

Water shortage can reduce crop transpiration (T) either by affecting vegetative growth, thereby reducing the size of the canopy, or by closing stomata, thus reducing canopy delivery. Because of the linearity between radiation interception and biomass production, reducing T by developing small blinds usually reduces white phosphorus and should be avoided in intensive gardening (Hsiao, 2000). Another option, regulating the T canopy by closing the stomata, presents some

interesting differences and exploitation between horticultural crops. It is well known that T is controlled by stomata. The transpiration of the parasols is regulated by the air conductivity and the canopy, and the extent to which T is affected by changes in the stomata conduction depends on the relative size of the two. Long rough umbrellas such as those in orchards have much more aerodynamic connectors than those short, smooth shades for field crops and vegetables. Tree curtains are well coupled with the atmosphere and exchange CO2 and H2O effectively with their environment, while short awnings, especially under low winds, are poorly coupled and provide greater resistance to mass transfer (Jarvis and McNaughton, 1986).

CROP WATER REQUIREMENTS

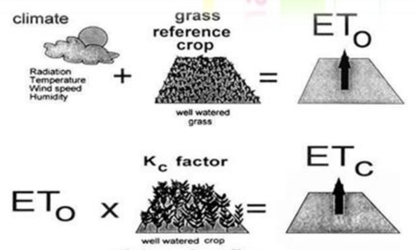
The crop water requirements = the rate of evapotranspiration.

- **DEFINATIONS**
- **1-Evapotranspiration (ETc)**

the quantity of water transpired by plants during their growth plus the moisture evaporated from the surface of the soil and the vegetation.

- **2-Reference crop evapo-transpiration (ET0)**
- **The rate of evapo-transpiration from an extended surface of 8 to 15 cm tall green grass cover of uniform height.**
- **3-The crop coefficient (kc) is selected for given crop and stage of crop development under prevailing climatic condition.**
- **Generally the water consumptive use for crops :**

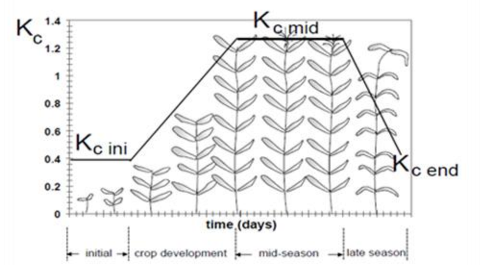
$$ETc = Kc * ETo$$



From ETo and estimates of crop evaporation rates, expressed as crop coefficients (Kc)
ETcrop = Kc × ETo

Under weak pairing, the stomatal closure increases the temperature of the crop, which in turn leads to an increase in the vapor pressure gradient between the leaf and the atmosphere, which increases T. In this case, stomatal control is ineffective in controlling T and significant decreases in its size (this It also affects photosynthesis significantly) There is a need to reduce canopy T. On the contrary, in well-coupled orchards, effective heat transfer from leaves prevents a significant difference between canopy and air temperature and there is almost a linear relationship between transpiration and canopy conductor. The olive trees work 3 meters high and about 50% of the ground cover, Villalobos et al. (2000) found a relative sensitivity to T for changes in canopy connection of about 0.9 during most of the day.

Crop Coefficient (Kc) Curve



crop evapotranspiration under different conditions

Crops	Kc mean	ETo {mm/day}						ETc {mm/day}					
		CH	CD	WH	WD	HH	HD	CH	CD	WH	WD	HH	HD
TOMATOES	0.65	3.12	4.45	4.45	5.70	6.35	9.55	2.03	2.89	2.89	3.71	4.13	6.21
POTATOES	0.84	3.12	4.45	4.45	5.70	6.35	9.55	2.62	3.74	3.74	4.79	5.33	8.02
CORN	0.80	3.12	4.45	4.45	5.70	6.35	9.55	2.50	3.56	3.56	4.56	5.08	7.64
SORGHUM	0.75	3.12	4.45	4.45	5.70	6.35	9.55	2.34	3.34	3.34	4.28	4.76	7.17
WHEAT	0.65	3.12	4.45	4.45	5.70	6.35	9.55	2.03	2.89	2.89	3.71	4.13	6.21
APPLE	0.85	3.12	4.45	4.45	5.70	6.35	9.55	2.65	3.78	3.78	4.85	5.40	8.11
CHERRIES	0.85	3.12	4.45	4.45	5.70	6.35	9.55	2.65	3.78	3.78	4.85	5.40	8.11
WALNUTS	0.85	3.12	4.45	4.45	5.70	6.35	9.55	2.65	3.78	3.78	4.85	5.40	8.11
PEACHES	0.75	3.12	4.45	4.45	5.70	6.35	9.55	2.34	3.34	3.34	4.28	4.76	7.16
PLUMS	0.75	3.12	4.45	4.45	5.70	6.35	9.55	2.34	3.34	3.34	4.28	4.76	7.16
COFFEE	0.90	3.12	4.45	4.45	5.70	6.35	9.55	2.81	4.01	4.01	5.13	5.72	8.60

Where:
Kc crop coefficient
ETo reference crop evapotranspiration
ETc crop evapotranspiration.
CH cool humid **CD cool dray** **WH warm humid**
WD warm dray **HH hot humid** **HD hot dray**

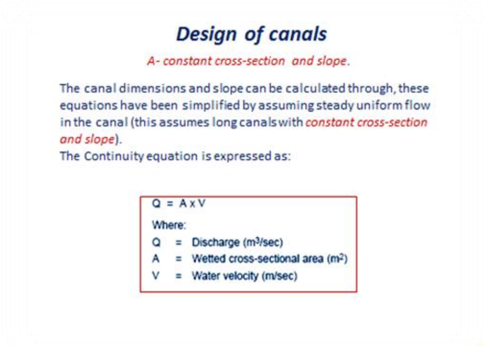
Thus, a specific decrease in the stomatal conduction will reduce the olive T approximately by the same amount. By contrast, similar measurements on garlic with a full cover showed the sensitivity of T to a decrease in stomata less than 0.3, which means that a relative decrease in T would be less than 30% a decrease in the conduction Villalobos et al. (2000). Thus, it is clear that closing stomata will have a variable effect on T depending on the characteristics of the crop canopy and its environment.

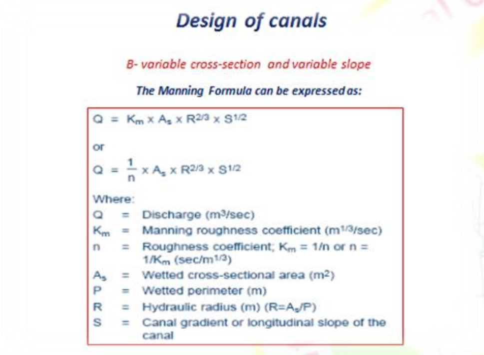
Irrigation Methods

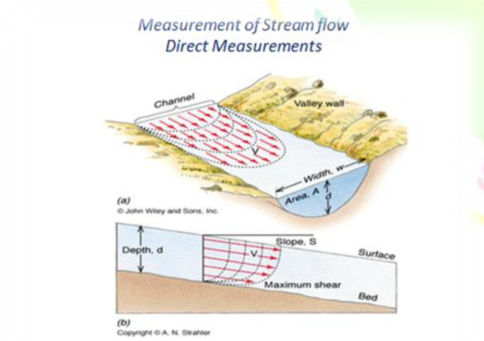
There are a number of surface irrigation techniques used in gardening but all of them have basic limitations. The depth of the applied water is determined by the rate of soil leakage. With surface irrigation, better engineering designs, management, and ground preparation (laser leveling), new technologies are now being used to control the depth of application and distribute water as uniformly as possible across the field. However, the inherent variation in soil water consumption rates cannot be overcome, and hence the variation in infiltrated water within the field.

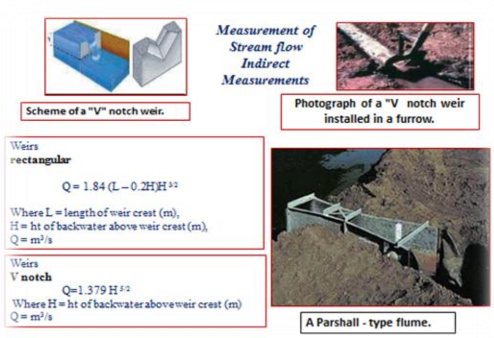
Where leveling was not possible, and although the initial spray systems had more work requirements than surface systems, the current robotic and solid group systems required little labor. The uniform distribution of water applied by wind spray is affected which also leads to increased spray evaporation and loss of drift in arid climates. Moreover, sprinkler irrigation can be problematic in orchards due to the parasol's interception of spray patterns resulting in poor distribution.

Gardeners and the general public work to link drip irrigation or drip irrigation using water efficiently. Drip irrigation consists of a permanent system of plastic tubes that use transmitters to locate water near individual plants using the high-frequency application and low discharge rates.

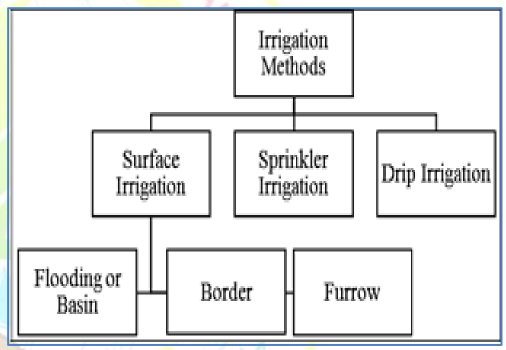


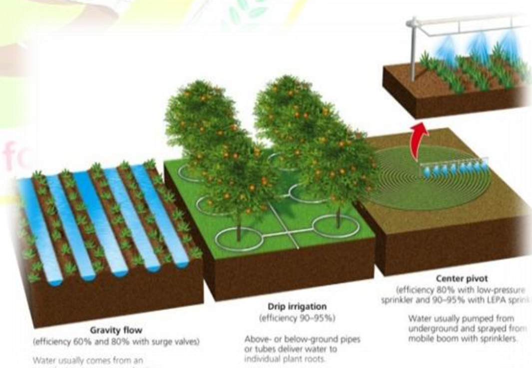






Surface irrigation can be effective in regular soils with moderate to low leakage rate but inactive in heterogeneous and / or with light tissues. The invention of sprinkler irrigation in the 1940s dominated the distribution of leaky water away from the soil. It was then possible to apply any required depth to areas First research reports on this method emerged several years after they were made available commercially (Goldberg et al., 1971). Research has shown that in addition to improving uniformity in water distribution, drip irrigation can increase the efficiency of fertilizer use by direct injection, allow better field access to equipment, reduce fungal diseases associated with moisture, and reduce the spread of weeds. On the other hand, controlling weeds in frequently wet areas has proven difficult due to the accelerated breakdown of herbicides (Fereres and Goldhamer, 1990). Small sprinklers, an extra-distillation technique for drip technology, moisten a larger surface area in various typical shapes and operate at a frequency between drip sprinklers and conventional impact sprinklers. It is also easy to find out if the small sprayers are clogged.





Different Methods of Irrigation

Furrow lengths in metres as related to soil type, slope, stream size and irrigation depth

	Soil type		Clay		Loam			Sand	
				Average irrigation depth (mm)					
Furrow	Maximum								
slope	stream size	75	150	50	100	150	50	75	100
%*	(l/sec)								
0.05	3.0	300	400	120	270	400	60	90	150
0.10	3.0	340	440	180	340	440	90	120	190
0.20	2.5	370	470	220	370	470	120	190	250
0.30	2.0	400	500	280	400	500	150	220	280
0.50	1.2	400	500	280	370	470	120	190	250
1.00	0.6	280	400	250	300	370	90	150	220
1.50	0.5	250	340	220	280	340	80	120	190
2.00	0.3	220	270	180	250	300	60	90	150

Basin area in m^2 for different stream sizes and soil types

Stream size (l/sec)	Sand	Sandy loam	Clay loam	Clay
5	35	100	200	350
10	65	200	400	650
15	100	300	600	1 000
30	200	600	1 200	2 000
60	400	1 200	2 400	4 000
90	600	1 800	3 600	6 000

Sprinkler Irrigation Systems

Design of pipe lines

pressure variation and head losses

1-the system should be designed for good distribution of water supply.

2- Each hose should provide about the same amount of water ± 5%.

3-The pressure variation within the system should not exceed 20% of the head losses in the hose.

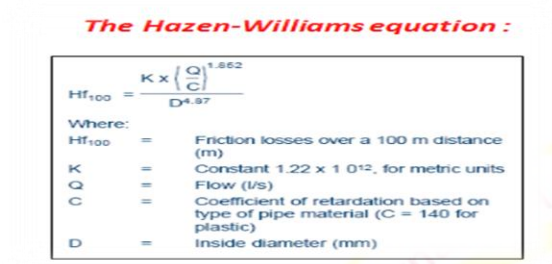
4-The Hazen-Williams equation will be used for this purpose.

Maximum border strip widths and lengths for smallholder irrigation schemes

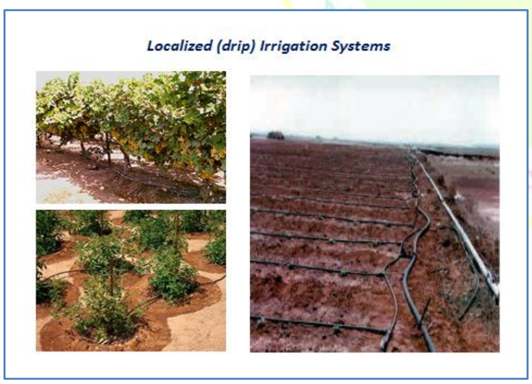
Soil type	Borderstrip slope (%)	Unit flow per metre width* (l/sec)	Borderstrip width (m)	Borderstrip length (m)
Sand	0.2-0.4	10-15	12-30	60-90
(Infiltration rate greater than 25 mm/h)	0.4-0.6	8-10	9-12	80-90
	0.6-1.0	5-8	6-9	75
Loam	0.2-0.4	5-7	12-30	90-250
(Infiltration rate of 10 to 25 mm/h)	0.4-0.6	4.6	9-12	90-180
	0.6-1.0	2-4	6	90
Clay	0.2-0.4	3-4	12-30	180-300
(Infiltration rate less than 10 mm/h)	0.4-0.6	2-3	6-12	90-180
	0.6-1.0	1-2	6	90

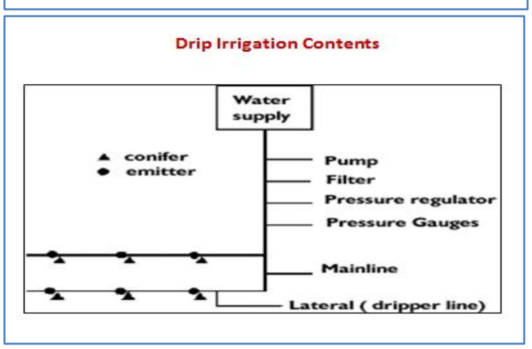
The operational and administrative advantages of sprinklers and small irrigation systems (drip and micro sprinkler) have led to a major shift in the United States from surface irrigation to these compact methods. Howell (2001) reported that between 1979 and 1994, the surface irrigated area in the U.S. decreased from two-thirds to half the total irrigated land and particularly noted that the use of micro-irrigation grew

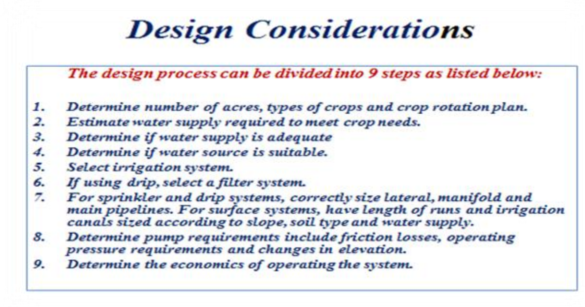
very rapidly during this period with an annual growth rate of more than 400%. This area reached one million hectares in 2000, or 5% of the total irrigated area. Within the United States, California has the largest area in small irrigation, but many other states, including Florida, Georgia, Hawaii, Michigan, and Texas, have a large area located in wet areas. The irrigation systems now in place are more than sufficient to provide gardening a wide range of options for applying water efficiently and uniformly, to the point that economic and social considerations often determine the final choice of method and equipment.

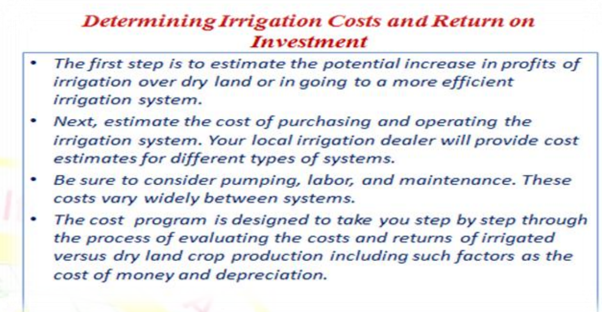


Sprinkler irrigation system









Irrigation Scheduling

Irrigation scheduling is a systematic method by which a product can determine the time of irrigation and the amount of water to be used. The goal of an efficient scheduling program is to supply plants with adequate water while reducing losses to deep filtration or runoff. The scheduling of irrigation depends on the soil, crops, atmosphere, irrigation system and operational factors. Correct scheduling of irrigation requires a sound basis for making irrigation decisions. The level of decision making ranges from personal experience to adopting practices and techniques based on computer-assisted tools that can assess soil, water and the atmosphere. Irrigation scheduling techniques can be based on soil water measurement, meteorological data, or plant stress monitoring. Conventional scheduling methods are measuring soil water content or calculating or measuring evaporation rates. Research into plant physiology led to tabulation methods by monitoring leaf swelling pressure, stem diameter, and sap flow.

With surface and portable sprinkler irrigation techniques, and the work to be completed, therefore, the primary management objective was to irrigate as regularly as possible. The primary concern is the conformity of applications to crop requirements. While most irrigation uses intuitive or qualitative approaches to tabulation, this topic has been extensively studied in horticulture and several quantitative measures have been proposed based on the water and soil budget and plant indicators. Water budget method is perhaps the most widely used scheduling technique. With surface irrigation, the approach is to calculate the storage of available soil water and the permissible depletion

threshold.Then, adjusted precipitation and irrigation inputs are balanced for efficient application versus ET crop yields, runoff and filtration. The increased availability of local and regional ET data, and the expansion of micro irrigation, where water budget information is more easily implemented, has encouraged farmers to adopt a water budget technology. Leading computer models by (Jensen et al., 1970), which have enhanced scientific irrigation scheduling in the United States over the past three decades, have contributed to the success of this technology.

Soil moisture monitoring is another scheduling procedure used in gardening. The first device used to measure the state of soil water was a tonometer, developed by LA Richards (Richards and Neal, 1936). Historically, the main threshold for tonometer was the relatively narrow range of action of soil water potentials, which made its use with surface irrigation methods problematic due to the wide range of soil water contents between irrigation. Hence, it was best used for irrigation management in shallow and / or sandy soils. Rather than assessing the potential of soil water, the neutron probe measures the moisture content, and can therefore be used to assess the quantities of water needed to refill soil features. However, the continuous decrease in surface irrigation, where this information is the most applicable, and the increased regulatory requirements for radioactive materials at the present time dampen enthusiasm for this monitoring technique.

The past decade has seen renewed efforts to develop a new generation of soil moisture sensors based on certain electrical properties, such as resistance, capacitance, and reflection time field measurement. New features include continuous monitoring and assessment of trends using appropriate software. All of these new sensors require very accurate fixation due to the very small measurement field. An important limitation of soil moisture monitoring is the difficulty in adapting to the spatial diversity of soil water properties and the distribution of irrigation water.

Although improving plant biomass or fruit production is the goal of irrigation, the plant is rarely the primary focus of irrigation scheduling techniques. Although there are a variety of methods for assessing the state of plant water directly or indirectly, there are few suggestions for using such measurements to schedule irrigation in gardening (Peretz et al., 1984; Shackel et al., 1997). Infrared temperature measured canopy temperature (Jackson et al., 1977), an indirect measurement technique used in agricultural crops, and now improved knowledge of plant responses to water along with recent developments in monitoring equipment and sensors is generating renewed interest in scheduling approaches ,this is for irrigation of fruit trees.

WATER TESTING FOR IRRIGATION SYSTEM

WATER QUALITY PARAMETER	LEVELS		
	NORMAL	HIGHER	SEVERE
1. PH	6.5-8.5	8.5-9.0	>9.0
2. ELECTRICAL CONDUCTIVITY	0.0-0.8	0.8-3.0	>3.0
(MMHOS/CM)	0-150	150-200	>200
3-EXCHANGEABLE SODIUM DISSOLVED	0-500	600-1000	>1000
(PPM)	0-200	200-600	>600
4-TOTAL SOLIDS (PPM)	0-200	200-600	>600
5-BICARBONATES (PPM)	0-60	60-100	>100
6-CARBONATES (PPM)	0-25	25-40	>40
7-CALCIUM (PPM)	0.0-3.0	3.0-9.0	>9.0
8-MAGNESIUM (PPM)	0.0-0.1	0.1-0.4	>0.4
9-SAR (PPM)	0.0-140	140-350	>350
10-IRON (PPM)	0-20	20-50	>50
11-CHLORIDES (PPM)			
12-SULPHATES (PPM)			

SOIL TESTING LEVELS FOR IRRIGATION SYSTEM

SOIL TESTING	LEVELS
1-PH	< 6 ACIDITY 6.1 –8.5 GOOD 8.6-9.0 TURNING TO ALKALINE >9.0 ALKALINE
2-SALINITY (MMHOS /CM)	<1.0 GOOD 1.0-2.0 HARMFUL FOR GERMINATION >2.01 HARMFUL FOR CROP GROWTH
3-ORGANIC CARBON (%)	1. – 0.2 VERY LESS 0.2 – 0.4 LESS 0.41 – 0.6 MEDIUM 0.61 – 0.8 TO MUCH >0.8 EXCESS
4-NITROGEN (KG/HA)	1.– 50 VERY LESS 51 – 100 LESS 101 –150 NORMAL 151 - 300 GOOD >300 EXCESS
5-PHOSPHOROUS (KG/HA)	1.–15 VERY LOW 2.- 30 LESS 31 - 50 MEDIUM 51 - 65 TO MUCH >65 EXCESS
6-POTASSIUM (KG/HA)	1.–120 VERY LESS 121 –180 LESS 181 –240 MEDIUM 241 – 360 GOOD >360 EXCESS
7-SOIL TEXTURE	SANDY SANDY LOAM LOAMY CLAY LOAM CLAY

The specific parameter for measuring plant water state is water potential (Hsiao, 1990). Shackle et al. (1997) suggested the use of the stem, which is measured on a covered sheet, making it less associated with the atmospheric environment and less varied than leaf measurements influenced by the behavior of stomata and the date of leaf shade. Naour (2000) found that the stem was a better indication of water stress than dawn or noon leaves. Another indicator of the state of the water is based on the daily stem diameter fluctuations that are directly related to changes in the state of the plant water (Klepper et al., 1971). Recent developments in sensor technology allow continuous monitoring of stem or fruit diameter (Huguet et al., 1992).

The commercial adoption of these indicators for tabulation requires knowledge of how measurements affect yields, which is a complex issue due to the difference in species and processes in their sensitivity to water stress. However, there are some promising commercial methods of plant scheduling for watering fruit trees, such as those suggested by Lampinen et al.

Soil Moisture, Appearance and Description Chart				
Available water [1]	Feel or Appearance of Soil			
	Sand	Sandy loam	Loam/Silt loam	Clay loam/Clay
> 100%	Free water appears when soil is bounced in hand.	Free water is released with Kneading.	Free water can be squeezed out.	Puddles; free water forms on surface.
100%	Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. (1.0)[2]	Appears very dark. Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. Makes short ribbon. (1.5)[2]	Appears very dark. Upon squeezing, free water appears on soil, but wet outline of ball is left on hand. Will ribbon about 1 inch. (2.0)[2]	Appears very dark. Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. Will ribbon about 2 inches. (2.5)[2]
75-100%	Tends to stick together slightly, sometimes forms a weak ball with pressure. (0.8 to 1.0)[2]	Quite dark. Forms weak ball, breaks easily. Will not slick. (1.2 to 1.5)[2]	Dark coloured. Forms a ball, is very pliable, slicks readily if high in clay. (1.5 to 2.0)[2]	Dark coloured. Easily ribbons out between fingers, has slick feeling. (1.9 to 2.5)[2]
50-75%	Appears to be dry, will not form a ball with pressure. (0.5 to 0.8)[2]	Fairly dark. Tends to form a ball with pressure but seldom holds together. (0.8 to 1.2)[2]	Fairly dark. Forms a ball, somewhat plastic, will sometimes slick slightly with pressure. (1.0 to 1.5)[2]	Fairly dark. Forms a ball, ribbons out between thumb and forefinger. (1.2 to 1.9)[2]
25-50%	Appears to be dry, will not form a ball with pressure. (0.2 to 0.5)[2]	Light coloured. Appears to be dry, will not form a ball. (0.4 to 0.8)[2]	Lightly coloured. Somewhat crumbly, but holds together with pressure. (0.5 to 1.0)[2]	Slightly dark. Somewhat pliable, will ball under pressure. (0.6 to 1.2)[2]
0-25%	Dry, loose, single-grained, flows through fingers. (0 to 0.2)[2]	Very slightly coloured. Dry loose, flows through fingers. (0 to 0.4)[2]	Slightly coloured. Powdery, dry sometimes slightly crusted, but easily broken down into powdery condition. (0 to 0.5)[2]	Slightly coloured. Hard, baked, cracked, sometimes has loose crumbs on surface. (0 to 0.6)[2]

[1] Available water is the difference between field capacity and permanent wilting point.
[2] Numbers in parentheses are available water contents expressed as inches of water per foot of soil depth.

(2001) to use the trunk in the plum. Ebel et al. (1995) suggested using fruit growth to schedule irrigation in apples and Goldhammer and Ferreris (2001) presented protocols based on stem diameter measurements for irrigation scheduling in orchards.Reducing Irrigation Needs In Horticulture

As the population grows, there is no doubt that in the near future some of the water currently used by agriculture will be diverted to the competing sectors of society. For horticultural crops in intensely irrigated areas such as California and Florida where the use of drip and small irrigation has become widespread, the efficiency of application in well-designed, maintained and managed systems is already high. The two required components of the water budget approach to irrigation scheduling Kc and ET were created with decades of research.

Reducing Surface Evaporation

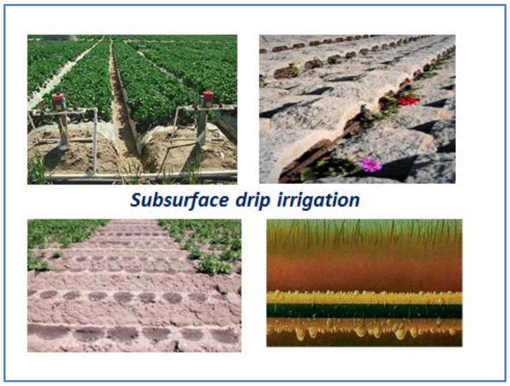
One of the obvious methods of reducing ET is to reduce or eliminate E because it has no direct effect on crop production as with T. In vegetable crops, potential E savings by switching to drips are negligible, as evaluated in a scale study Thaw, where the drip ET and the tomato irrigated were equal (Pruitt et al., 1984).

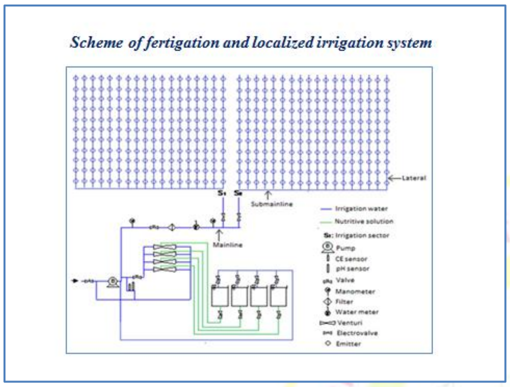
However, in tree crops, E savings in the early years of the orchard are significant when the surface system is changed to small irrigation (Fereres et al., 1982). During the past two decades, drip emitters have been developed to combat root infiltration, which is the most troublesome factor in developing subsurface drip.

Irrigation Deficit and Stress Management

Not using cultivated areas or switching to winter crops that use less water than summer crops is the most direct way to reduce water demand for modern and efficient agricultural operations and is to reduce the actual consumption of plants. Impotence irrigation is the application of water below the ET rate and can be done in many fashions. Deficient or continuous irrigation of the deficit is the systematic application of water in a fixed portion of the probable ET throughout the season. RDI is implemented by imposing water deficits only at certain stages of crop growth (Chalmers et al., 1981). It should be understood that, depending on the levels of stored soil water and rainfall patterns and amounts, deficient irrigation may or may not reduce ET to its maximum potential.

The potential to provide irrigation water from the deficit of orchard crops has not been explored relatively yet. This is due to the lack of irrigation in most field and zero crops, the oldest and most researched crop plants usually reduces yields, and therefore the profit is directly proportional to the size of the ET deficit. The prospects for reducing ET in many vegetable crops are also limited because most relationships between the crop and ET are linear. However, the nature of tree crop production, where fruit instead of biomass is a marketable product and the quality of the fruit is important, provides the ability to use irrigation deficits to reduce water use while maintaining farm profitability or even improving it without changes in the cultivated area and / or patterns Crops.





Increase the area where impotence irrigation can be used effectively to save water by reducing T. The initial work of RDI in the 1970s in Australia and New Zealand was aimed at reducing vegetative growth and, consequently, summer pruning, in late-ripening peach trees. Associated water savings were of secondary importance. The researchers succeeded in maintaining or even increasing yields when they stressed only trees in the slow fruit growth stages and saved about 25% of potential ET (Mitchell et al., 1989). Researchers in Spain and California tried to reproduce these results under different conditions and failed (Girona et al., 1993, 2002; Goldhamer et al., 2002). This explains the specificity of RDI results and how convertibility requires adjustments to diversity, soil type, and evaporative demand.

A common feature of many impotence irrigation systems is the improvement of fruit quality, as has long been reported by Oreo and Magnes (1967). The protests carried out numerous experiments that clearly demonstrated that mild water deficits enhance the quality of apples (Proebsting et al., 1984). By working with mature navel oranges, Goldhamer and Salinas (2000) found that the yields of the applied fruit and water are linearly related but with a slope above the 1: 1 relationship.

Unlike the appearance of fruit, horticultural crops often have other unique productive ingredients that can be used to reduce T without reducing farm profit. One example is the hydration of fruits in peach orchards. Goldhamer et al. (1994), Mabinin et al. (2001) showed that within 6 to 8 weeks before harvest, water stress can reduce fruit hydration without affecting the weight of dry fruits or the subsequent load of fruits. In addition, energy is provided and 200 to 250 mm of water, as the plum should be dried in the ovens. The rapid growth of the nucleus and shell structure occurs in the first three to four weeks of the season but the rapid growth of the nucleus does not begin until about week 10. Therefore, RDI (100 to 200 mm of water below potential ET) can be imposed between these two periods without negative effects on production (Goldhamer and Beede, 1992). In the olive, Moriana et al. (2003) demonstrated that the relationship between ET and yield is linear.

Deficient irrigation after harvest may be another way to conserve water in some species. Larson et al. (1988) With peach trees in the early harvest season, reducing the number of surface irrigation after harvest by more than half did not adversely affect the production of orchards later. A distinction must often be made between the current and potential positive effects of RDI. An example of this can be found in almond trees. Goldhamer and Viveros (2000) have demonstrated that the moderate stress imposed by the SDI system (water applied at 85% of ET) does not affect production. However, potentially more significant outcomes included medium to severe RDI systems prior to the harvest (April-July). These strategies reduced the size of the parachute and the weight of the individual core but had no effect on the fruit load.

In other words, smaller and smaller RDI trees have a higher fruit density than fully irrigated trees. Consequently, increasing the intensity of cultivation under RDI can increase yields compared to fully irrigated orchards with standard intensity. Moreover, this type of RDI will address two critical health issues facing the industry - agricultural burn and dust during harvest. The first will be reduced or eliminated due to a significantly lower vegetative drop and pruning residue. The latter will be eliminated because earlier splitting of the structure Goldhamer and Viveros (2000) will allow the nuts to dry on the trees and be harvested directly into boxes or carriers, rather than drying and harvesting on the ground, which is the current practice that produces dust during wiping and nut retrieval. Ant damage and soil borne bacteria infection will also be eliminated using this RDI-driven technology. Grape is another crop where stress management has improved the quality of fruits. In fact, it was illegal to irrigate wine grapes until recently in some countries, such as Spain, simply because of the noticeable negative impact on the quality of wine.

The lack of water reduces the size of the berries at harvest and thus increases the ratio of the skin to the pulp, resulting in a more appropriate color and flavor. The lower RDI yield is reflected in the smaller and lesser berries per cluster and fewer clusters per vine. Ecologists usually say this is more than compensating for the improved wine quality. Recently, the beneficial

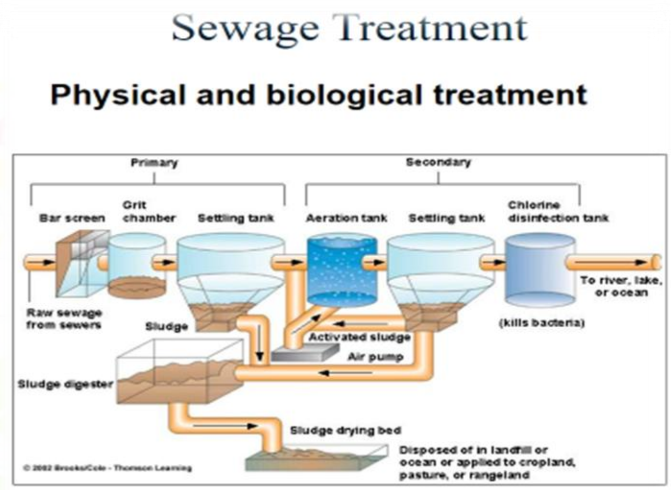
aspects of root zone partial drying (PRD) - a technique where deficits are applied by alternating watering on each side of the tree or vine almost every two weeks on wine grape production has gained much attention as a technique that applies RDI to improve wine quality while reducing T (Stoll et al., 2000). The hypothesis behind this approach is that hormonal signals from the dry part of the roots change the division and reduce vegetative growth, allowing better penetration of light that improves the quality of the fruit.

However, Goldhamer et al. (2002) on Peaches and Caspari et al. (2002) on comparing apples to traditionally applied RDI and PRD systems reported no differences in yields and quality standards between placement methods and thus do not support positive claims by PRD supporters of these two types. Reducing the crop water requirements in gardening should be based on a systematic assessment of the benefits of managing stress. There is an urgent need to invest in the research needed to document the benefits of stress in terms of 1) improving fruit quality, 2) reducing consumer use or irrigation requirements, and 3) improving farmers 'profits. Without proven benefits, stress management strategies will not be adopted by most farmers.

Increasing Supplys: The Use of Reclaimed Water

An indirect benefit of irrigation deficiency is the more efficient use of precipitation, as partial water depletion of the soil allows rain to be captured within the crop root zone, thus reducing drainage losses. Current developments in weather forecasting can help develop flexible deficit irrigation strategies that leave some storage capacity for expected rain. Future irrigation schedules should be designed to achieve the most effective use of monsoons as a means of increasing available supplies. Alternative water is the source of water. Treated water is treated wastewater that is recycled and used again. In the past, urban wastewater disposal has generally been dealt with by treating wastewater and then disposing in a more appropriate manner. Usually, this means draining water in a nearby river or lake, spraying it on a field, or loading it into a filtration pool. Disposal was the primary consideration as the amount of wastewater continued to increase as an unavoidable consequence of population growth. With the increase in the volume of wastewater, concerns have been raised about the impacts on the drainage sites. This led to consideration of alternative uses such as irrigation.

Florida citrus growers initially refused to use reclaimed water because of concerns about potential heavy metal contamination, potential disease problems, floods, and a lack of flexibility in water use during periods of heavy rains. Farmers also raised concerns about public perceptions and feared the degradation of the quality of fruit from trees irrigated with treated water. Fears proved to be unfounded, and citrus performance was very good even at excessive irrigation rates (2500 mm / year) with treated water (Parsons et al., 2001). Reclaimed water is now used in about 80,000 hectares of public access areas, golf courses, and agricultural crops in Florida (Florida DEP, 2002). Many severe droughts have increased interest in the use of reclaimed water, and Florida now leads the nation in its total reuse flow, followed by California, Texas, and Arizona. The four states that account for more than 90% of water reuse in the United States will continue and a reliable source of irrigation water will continue to be used in Future increase.



Reusing Treated Wastewater in Agriculture; Degree of Treatment, Kind of Plant & Soil, and Method of Irrigation

Group	Degree of Treatment	Plants	Environmental & Health Precautions	Suitable Irrigation Methods	Proposed Kind of Soils
First	Primary	Trees for Timber Bio fuel plants	Fencing farms No direct contact with water and entrance of farm workers only Prohibit from entering farms Take health measures required for the protection from infection with pathogenic organisms and treatments	Furrow	Light texture authorized for use in desert land 5 km away from dwelling communities while complying with periodical assessment of the environment
Second	Secondary	Palm trees, cotton, flax, linen, jute Fodder crops & dried cereals Husky fruits & crops Cooking vegetables Heat processed fruits Flower nurseries Raw edible plants Husky plants	Cattle not yielding milk, and producing met could be used Food should be cooked prior to eating	Furrow & sprinkling	Light medium texture
Third	Advanced	All kinds of horticulture crops Fodder & green grasses	None	All methods except spraying	All kinds for soil

Strategic Water Resource Management In Horticultural Crops

Strategic management of water resources refers to all competing water demands and seeks to allocate water on a fair basis to meet all uses and demands. The will to treat and reuse water has a crucial role in sustainable

development in the public, industrial and agricultural sectors. There are technologies in place to control many types of pollutants. The future challenge will be to control micro-pollutants and heavy metals. For water-intensive industries, reducing water consumption will become a necessity, and will be a major factor determining the market compatibility of industrial products. For the agricultural sector, new irrigation techniques will be required to minimize water consumption and prevent unsustainable groundwater extraction. Strategic water management is activities related to planning, development, distribution and management of the optimal use of water resources.

One fifth of the world's population, more than 1.2 billion people, live in water-scarce regions, where there is not enough water to meet all demands. An additional 1.6 billion people live in areas with economic water scarcity, where a lack of investment in water or insufficient human capacity makes it impossible for the authorities to meet the demand for water.Improvements have been made in the standardization of irrigation application and scheduling management steadily over the past century, which has resulted in increased water productivity, especially for horticultural crops. Low water availability, high costs, and increasing environmental concerns for agricultural water transfers are issues that farmers will not be able to ignore in the future. The solutions will not be easy and possibly multifaceted. The reuse of wastewater in selected agricultural crops is sure to expand. However, we believe that opportunities to improve application efficiency and develop new supplies of agricultural water will be increasingly limited in the future.

There are greater possibilities for developing more accurate methods for scheduling irrigation that use soil and more clearly the state of crop water as catalysts for applying irrigation water. This will require better technologies to monitor the state of the water, including robust and affordable sensors that can be linked to automatic system controllers.

In the future, the use of structured disability irrigation (RDI) should be more widespread, especially in areas with high water costs and high value crops. R&D innovation will depend on farmers 'awareness that they can save large amounts of water while managing water stress to improve some yield components in a number of important tree and vineyards. More broadly, the improved availability of more accurate ET information will increasingly encourage the adoption of scientific scheduling for irrigation where plant stress is not desirable. As research continues to provide new information and technologies, the often hostile relationships between urban, agricultural, and environmental interests in water resources are likely to be replaced by a more cooperative atmosphere created around established scientific facts.

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Research Article

Effect of short-rotation trees on nutrient dynamics and rooting pattern in intercropped with aromatic grasses in terai of U.P.

Faiz Mohsin[1*], Afreen Mohsin[2] and S.S.Dhaka[3]
[1]*Krishi Vigyan Kendra, Rampur, SVPUAT, U.P., India*
[2]*Forest Research Institute, DehraDun, India*
[3]*Krishi Vigyan Kendra, Pilibhit, SVPUAT, U.P., India*
**Corresponding author e-mail: drfaizmohsin@gmail.com*
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ABSTRACT
An Experiment was conducted in District Pilibhit.U.P., to study the yields of aromatic grasses in pure fields as well as intercrops under *Populus deltoids* and *Eucalyptus hybrid*. Quantity of litterfall, its chemical composition, nutrient addition, changes in chemical constituents of soil and herb and oil yield of *Cymbopogon spp*. were studied under agroforestry systems involving *Populus deltoids* and *Eucalyptus hybrid* with intercrop of Aromatic grasses (*C.winterianus, C.martinii, C.flexouses*). Trees were intercropped with grasses have significantly more diameter and height in comparison to trees planted without intercrops. High herbage and oil yield was recorded in pure fields of grasses than their crops intercropped with trees. Maximum yield was produced by Palmarosa and minimum by Citronella in poplar plantation intercropped. In *Eucalyptus hybrid* intercropped grasses, maximum oil yield was produced by Lemon grass and minimum by Palmarosa. Higher quantity of litter was produced in Palmarosa and lower was produced in Citronella intercropped trees. The litter produced by the intercropped stands had higher NPK contents than pure stands. The concentration of nutrients in the litter decreased with increasing age of the stands. Similarly, the total addition of nutrients (NPK) through litter fall to the soil increased as the age of trees increased. In the field of trees intercropped with Palmarosa was maximum addition of nutrients, while in Citronella intercropped field it was seen minimum. In comparison to intercropped stands, available NPK content of soil was higher in pure stands of trees. Maximum amount of N and K was found in superficial layer of the soil, which decreased with increasing depth. Most of the phosphorus was accumulated in the soil at the depth of 15-30cm in all the stands. The concentration of roots was more near the base of the trees at juvenile age,but as the age increases the roots tended to proliferates uniformly.. The total root biomass decreased continuously with increasing soil depth at all the radial distances and under all the age groups. It is clear that there is no completion among the root system with roots of intercrops grown along with Poplar and Eucalyptus.
Keywords: *Litterfall, Populus deltoids, Eucalyptus hybrid. Aromatic grasses, Nutrient return, Agroforestry system*

INTRODUCTION
The litter of the forest is an important stage in the cycle of habitat conservation. It provides the return of nutrients and the replenishment of organic matter and supports a wide variety of riches for fauna and micro-organisms. These species are covering the largest area in India among the exotics. crops such as medicinal herbs on farm land without than the slow growing and long rotation trees Prasad, et.al (1985). But at the same time, it is a winter deciduous tree species and produces a considerable quantity of litter fall in the winter season.

In North India, Eucalyptus plantation is again picking up under agrisilvicultural system due to introduction of colonel Eucalyptus having fast rate of growth, small canopy, uniform stem girth and 30 to 40 percent higher wood production Bhardwaj, et.al (2001).The amount and pattern of litter fall varies with the type of species, growth and age, tree density, canopy characteristics, intercrops, season, etc. (Bhardwaj, et. al 2001; Mohsin, et.al.1996 and Singh 1998).

The addition of litter fall and return of nutrients through litter fall, especially N. P. K have been quantified in many studies Mohsin (2005), Mohsin and Singh (2007) and Mohsin and Singh (2008)., but a meager information is available regarding return of nutrients through litterfall at farmers field.

Roots provide anchorage for the tree and serve the vital functions of absorption and translocation of water and nutrients.

They exert a significant influence on soil profile development, and upon dying, roots contribute to soil organic matter content (McClaugherty et.al.1982).

The difficulty in predicting the rooting pattern and root interaction of woody species in agroforestry is further compounded by the fact that the root systems of most tropical trees have been only scantily investigated (Halle et.al., 1978). Some of the reviews that are available on the work (Kerfoot,1963; Jenik,1977) indicate that for many woody species the largest number of roots, are located in the uppermost fertile portion of the soil profile.

Spatial distribution and biomass of roots in *E.camaldulensis* (Prasad et.al.,1984; Zohar,1985), E. grandis (Baldwin and Stewart,1987), *E. hybrid* (Dabral et.al.,1987), *E.tereticornis* (George,1985 and Dhyani et.al.,1990), *E. marginata* (Carbon et.al.,1980) and *E. globules* (Mathur et.al.,1984) plantation were studied.

Therefore, the study was carried out to assess the dynamic pattern and quantity of litter fall and to estimate the amount of nutrients return to soil during different months in plantations .

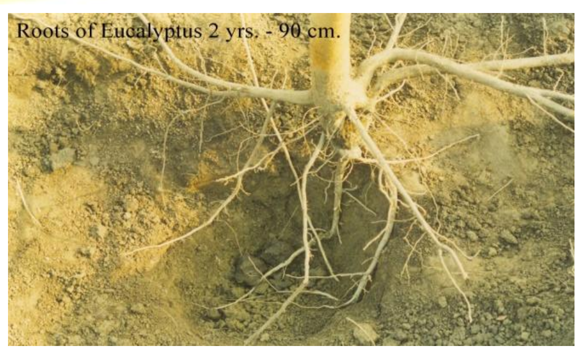
MATERIALS AND METHODS

Field experiment was conducted at farmers field in Distt. Pilibhit, U.P. for 72 - Months. Maximum and minimum temperature ranges from 18 to 47 C and 5.2 to 29.10 C, respectively. The agroforestry systems were *Poplus deltoides*(S7C15) and Eucalyptus hybrid with improved varieties of aromatic grasses viz., *Cymbopogon winterianus* (Bio-13), *Cymbopogon flexouses*(Krishna) and *Cymbopogon martini* (PRC- 1). There were seven treatments, in both the tree component; viz; three were with intercrops, three were of pure crop component of each aromatic grasses and one of pure *Populus deltoids* and *Eucalyptus hybrid.* The soil of experimental fields was typic Hapludoll derived from alluvium. It was silty clay loam having pH of 7.0, organic carbon 1.0%, available N,P and K were 272.5, 12.8 and 245.4 kg/ha, respectively. Trees of Poplar and Eucalyptus were planted at the spacing of 5m x 4m and 2.5m x 2.5m. All the above aromatic grasses were planted both as pure and intercropped with *Populus deltoids* and *Eucalyptus hybrid*, during first week of February at spacing of 60 x 60cm by slips in the first year of the study . A suitable fertilizer dose of 180 kg N, 80 kg Pand 60 kg K per hectare was applied to *Cymbopogon winterianus*. One third dose of N and total P and K was applied at the time of planting and

Rooting Pattern of *Populus deltoids* (Age: 2 Years, Depth : 45cm)

Rooting Pattern of *Populus deltoids* (Age: 5 Years, Depth : 45cm)

Rooting Pattern of *Eucalyptus hybrid*



Rooting Pattern of *Eucalyptus hybrid*

rest amount of N was applied in two equal doses after every harvest in *Cymbopogon winterianus*. In the second year, full dose of P and K was given and three equal doses of N applied after each harvest. In third and fourth year same doses of fertilizer were applied as in the second year. *Cymbopogon winterianus* continued for four years. In *Cymbopogon flexouses* and *Cymbopogon martini* same fertilizer dose was applied except N, i.e., 150 kg/ha.

From second to sixth year same fertilizer application was done as in *Cymbopogon winterianus* , *Cymbopogon flexouses* and *Cymbopogon martini* continued upto end of the study period i.e., 72 – months ,in pure as well as intercropped system. First weeding was done after 45 days of planting and second weeding was done after 90 days of planting. After each harvest of grasses, hoeing was done. Fifteen irrigation were given to these crops per year. First harvest of aromatic grasses were done in June and second harvest was done in October. From second to sixth year of study, three harvests were taken in the month of February, June and October each year, except *Cymbopogon winterianus*, in which only from second to fourth year of study three harvest were taken. Fresh herbage yield of aromatic grasses were recorded in each harvest by quadrate method.

A 100 gm sample of each crop at both harvest was collected and oil content was measured with the help of Clevenger's apparatus. Oil yield was also calculated.

The annual litter production of the trees in intercropping stands was recorded by collecting all the leaves and twigs, falling to the soil surface in litter traps made by demarcating 100 x 100 cm areas at six places. The litter samples collected were pooled together to represent annual fall. A represented sample of each annual litterfall were taken, oven dried at 80 C for 36 hrs. and subjected to further chemical analysis for N, P and K, using the modified microkjeldahl Vanadomolybdo phosphoric acid yellow colour method and flame photometry, respectively Jackson (1967). On the basis of nutrient concentration in the litter, the quantity of nutrient elements released and their periodical addition to the soil was calculated.

The pattern of root distribution of the Eucalyptus and Poplar trees was studied by excavation method as reported by Ghosh and Chattopadhyay (1972) and Chandra et.al.(1979). A circle of 150cm radius was marked around the tree trunk and further sub-divided

The roots were graded into following four classes (Aiyappa and Srivastava,1965), on the basis of their diameter measured with the help of vernier calipers.

1. g1 (Fibrous) = < 0.2cm
2. g2 (Thin) = 0.2- 0.5cm
3. g3 (Medium) = 0.5 – 1.5cm
4. g4 (Thick) = > 1.5 cm.

RESULTS AND DISCUSSION

Herbage and Oil Yield: The data recorded on the fresh herbage and oil yield has been given in Table – 1. It is revealed from the table that higher herbage and oil yield was recorded in all the aromatic grasses, in pure fields and then with intercropped with *Populus deltoides* and *Eucalyptus hybrid*. In *Cymbopogon winterianus*, the fresh herb yield (q/ha) and oil yield (kg/ha) increased upto third year but in fourth year the herb yield decreased. In *Cymbopogon flexouses* and *Cymbopogon martini* remained for 72-months in the field, but *Cymbopogon winterianus* remained only for 48 months. The fresh herbage and oil yield was recorded higher in pure crops than intercropped crops with trees. The herbage and oil yield recorded under trees was less due to increased amount of shade, in comparison to pure fields of aromatic grasses. Upto the age of 48- months of trees the yield of intercrops did not decreased but as the age increased to 60 and 72- months the yield was also decreased. This was due to canopy effect of trees.

In the study, it was recorded that herb yield was recorded highest in rainy season harvest continuing by winters and summers harvest. Similarly oil percentage of all the aromatic grasses was low in rainy and winter season than by summer season harvest.

Spectral composition and intensity of light on cell structures which are known as site of terpene formation can be explained for the oil percentage. light favours the formation of oil and stimulates the bio-chemical and physiological reactions during the bio-synthesis of oil. Thus, shorter period of sunshine due to clouds and more shade under trees, resulted in reduction of oil contents. These findings are in conformity with those of Dutt and Thakur (2004), Dabral, et.al. (1987) and Thakur and Dutt(2007).

Table 1: Total herb (fresh weight) and oil yield of aromatic grasses as affected by age and treatments in *Populus deltoids* and *Eucalyptus hybrid* plantations

Age (Months)	Herb Yield(q/ha)						Oil Yield(kg/ha)					
Treatments	12	24	36	48	60	72	12	24	36	48	60	72
C.winterianus (Pure)	160.4	250.5	265.1	200.0	-	-	128.3	200.4	212.1	160.0	-	-
C.martinii (Pure)	200.5	300.1	310.0	315.6	280.5	280.2	100.3	150.1	155.0	157.8	140.3	140.1
C.flexouses (Pure)	200.2	280.4	300.1	300.5	250.2	210.2	180.2	252.4	270.1	270.5	225.2	189.2
Poplar+C.winterianus	145.1	200.5	185.2	130.0	-	-	116.1	160.4	148.2	104.0	-	-
Poplar+C.martinii	180.4	240.5	217.2	158.2	140.1	140.6	90.2	120.3	108.6	79.1	70.1	70.3
Poplar+C.flexouses	180.5	238.6	240.5	240.0	175.4	147.8	162.5	214.7	216.5	216.0	157.9	133.0
Eucalyptus+C.winterianus	130.5	188.4	159.2	101.0	-	-	104.4	150.7	127.6	80.8	-	-
Eucalyptus+C.martinii	172.5	211.6	211.8	180.9	150.4	149.5	86.2	115.8	105.9	90.5	75.2	74.8
Eucalyptus+C.flexouses	170.7	210.2	186.8	142.5	118.9	114.7	153.5	189.2	168.1	128.3	107.0	103.2

	For Fresh herb yield		For Oil yield	
	Poplar	Eucalyptus	Poplar	Eucalyptus
CD at 5% for stand age(a)	0.089	0.082	0.078	0.074
CD at 5% for species mixture(b)	NS	NS	NS	NS
CD at 5% for interaction (axb)	0.0281	0.245	0.362	0.391

Litter Production

The total annual litter production (t/ha/yr) was lower in the juveline stands but it increased significantly ($P<0.05$) over time. The higher litter productivity in the intercropped stands of trees in the present study was expected due to cultural operations given to aromatic grasses, which have ultimately helped the trees in producing more number of twigs and leaves and thus increased litter production. The maximum litter production in intercropped trees than their pure stands was also found by Mohsin, F. and Baburam (2002) and Mohsin (2005). Highest litter production by trees with *Cymbopogon martini* and lowest with *Cymbopogon winterianus*, among the intercropped trees (Table-2).

Table 2: Total litter production (t/ha/yr) in *Populus deltoids* and *Eucalyptus hybrid* as affected by age and treatments

Treatments/ Age (Months)	*Total litter production (t/ha/yr)* 12	*24*	*36*	*48*	*60*	*72*
Poplar+ C.winterianus	*1.52*	*2.32*	*3.24*	*4.92*	*5.14*	*5.66*
Poplar+ C.martinii	*1.85*	*2.91*	*3.97*	*6.18*	*7.41*	*8.22*
Poplar+ C.flexouses	*1.63*	*2.64*	*3.45*	*5.21*	*7.26*	*7.71*
Poplar (pure)	*1.36*	*2.16*	*3.14*	*4.61*	*5.12*	*5.55*
Eucalyptus+ C.winterianus	*0.52*	*0.69*	*2.38*	*4.21*	*6.11*	*7.68*
Eucalyptus+ C.martinii	*0.66*	*0.77*	*2.76*	*4.46*	*6.81*	*7.89*
Eucalyptus+ C.flexouses	*0.61*	*0.74*	*2.49*	*4.35*	*6.32*	*7.75*
Eucalyptus (pure)	*0.43*	*0.58*	*2.14*	*4.09*	*5.92*	*7.49*

	Poplar	*Eucalyptus*
CD at 5% for stand age(a)	*0.091*	*0.075*
CD at 5% for species mixture(b)	*NS*	*NS*
CD at 5% for interaction (axb)	*0.282*	*0.261*

But it is also revealed that Poplar and Eucalyptus intercropped with *Cymbopogon winterianus* did not produce much litter, due to no intercrop in the age of 60 and 72- months of trees. It indicates that trees with *Cymbopogon martini* have big and fully developed canopy. Similar studies were also reported by Issac, et.al, (2004).

Nutrient Concentration in Litter

The concentration(mg/g) of NPK in the litter was found to be higher in the intercropped than that of pure stands at all the ages. The values remained higher in the stands intercropped with *Cymbopogon*, being maximum in the *Cymbopogon martini* and minimum in *Cymbopogon winterianus*, intercropped stands of all the ages in comparison to pure plantation of Poplar and Eucalyptus(Table-3). The concentration of nutrients in the litter decreased significantly($P<0.01$) with increasing age of the stands. Concentration of N,P and K in leaf litter is related to stand age and decline with successive growth of the tree ,Mohsin,et. al. (1996). and Mohsin and Singh (2007). The proportion of mature leaves in plant increases with the advancement of its age and the litter produced by the older trees therefore contain comparatively lower nutrient concentration on N and K in the intercropped stands at various ages was found.

Addition of nutrients into the soil

Though the concentration of nutrients decreased with increasing age of the stands but their addition to the the soil through litterfall was increased significantly with increasing age (Table-4). This was due to significant increase in the total litter production and advancement of the age of the trees in the stands Mohsin and Baburam (2002),Halle et.al.,(1978) and Jennik(1977). Agroforestry practices increase the soil organic matter through litter production which is responsible to enhance the population of ben eficial microorganisms. The soil biological attributes are also responsible for determination and maintenance of physical properties of soil.

Rooting Pattern of Poplar and Eucalyptus

The age of trees had a significant effect on its total root system. The total root biomass of 2 and 3 years old Poplar trees was about 2.11 Kg and 6.30 Kg, respectively; which increased to 21.98 Kg in 4 years and 28.36 Kg in 5 years old trees (Table-5).

The increase in root biomass may be attributed to variation of the growth rate of trees with age. Generally, the growth rate remained higher during early stages, it became constant or decreased with the advancement in tree age. Similar results have been reported by McMinu(1963) for Douglas Fir, Ruark and Bockheim(1987 Mohsin et.al. (2020)) for *Populus tremuloides* and *Populus deltoids* . In 2 and 3 years old trees the total root biomass decreased continuously with increasing radial distance from the base at all the soil biomass increased in 50-100 cm than 0-50 cm distance and decreased further in 100-150 cm distance (Table-10).

The results further indicated that in early stages, the roots of the trees were mostly concentrated near the base of the trees while in the later stages (4 and 5 years), the root system tended to distribute uniformly around the tree. Similar results on radial root distribution have been reported in Citrus (Aiyappa and Srivastava, 1965; Aiyappa et.al.,1968 and Chandra et.al.,1979); mango (Bojappa and Singh, 1975) and Guava trees (Hedge,1980). It was also noticed that the total root biomass decreased continuously with increasing soil depth at all the age groups. Similar results on root distribution with vertical depths have been reported in Slash Pine (Schultz,1972), *Pinus sylvestris* (Robert,1976) and *Populus tremuloides* (Ruark and Bockheim,1987).

Table 3: Nutrient Concentration (mg/g) in litter fall of *Populus deltoids* and *Eucalyptus hybrid* as affected by age and treatments

Age (Months)	12			24			36			48			60			72		
Treatments	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Poplar+ C.winterianus	1.08	0.11	0.76	0.93	0.09	0.68	0.66	0.08	0.54	0.53	0.07	0.49	0.42	0.07	0.41	0.37	0.06	0.34
Poplar+ C.martinii	1.17	0.11	0.82	1.07	0.10	0.77	0.78	0.09	0.68	0.69	0.09	0.61	0.54	0.08	0.56	0.51	0.07	0.47
Poplar+ C.flexouses	1.10	0.11	0.79	0.96	0.09	0.73	0.69	0.09	0.62	0.57	0.08	0.55	0.47	0.07	0.47	0.43	0.07	0.39
Poplar (pure)	0.96	0.10	0.71	0.84	0.08	0.63	0.51	0.08	0.49	0.42	0.07	0.42	0.36	0.06	0.35	0.29	0.05	0.36
Eucalyptus+ C.winterianus	8.9	0.53	7.1	7.4	0.46	6.2	6.7	0.42	5.6	6.1	0.38	5.2	5.5	0.36	4.8	4.5	.45	4.3
Eucalyptus+ C.martinii	9.3	0.55	7.3	7.7	0.48	6.4	7.1	0.46	6.1	6.4	0.43	5.8	5.8	0.41	5.2	4.8	.48	4.5
Eucalyptus+ C.flexouses	9.2	0.54	7.2	7.6	0.47	6.3	6.8	0.44	5.9	6.2	0.41	5.5	5.7	0.39	4.9	4.6	0.46	4.4
Eucalyptus (pure)	8.4	0.48	6.8	7.0	0.41	5.9	6.4	0.38	5.4	5.8	0.35	4.9	5.1	0.34	4.5	4.3	0.43	3.9

	Poplar			Eucalyptus		
	N	P	K	N	P	K
CD at 5% for stand age(a)	0.351	NS	NS	0.481	0.522	0.589
CD at 5% for species mixture(b)	0.582	NS	0.575	0.612	NS	0.591
CD at 5% for interaction (axb)	NS	NS	NS	NS	0.489	NS

Table – 4. Total addition of nutrients through litterfall (kg/ha/yr) of Populus deltoids and Eucalyptus hybrid as affected by age and treatments

Age (Months)	12			24			36			48			60			72		
Treatments	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Poplar+ C.winterianus	16.09	1.54	11.40	21.41	2.16	17.32	27.96	2.52	22.41	32.14	2.93	28.64	37.42	3.84	32.46	34.42	4.22	36.71
Poplar+ C.martinii	20.08	2.04	15.22	24.92	2.71	23.22	31.42	3.15	25.91	37.11	4.17	31.11	41.25	5.12	36.94	39.64	6.52	39.11
Poplar+ C.flexouses	17.61	1.81	12.49	23.12	2.32	19.12	29.16	2.86	23.89	34.63	3.42	30.21	39.71	4.26	34.16	37.53	5.27	37.13
Poplar (pure)	14.25	1.22	11.23	18.66	2.07	16.86	24.25	2.41	21.32	29.78	2.69	27.92	35.89	3.69	31.55	30.91	4.11	35.21
Eucalyptus+ C.winterianus	6.14	0.36	4.89	17.61	1.09	14.75	24.52	1.26	20.55	29.61	1.96	26.35	33.77	2.33	29.47	34.60	2.69	33.06
Eucalyptus+ C.martinii	6.78	0.40	5.32	21.17	1.32	17.60	28.69	1.89	25.92	33.24	2.34	27.96	35.72	2.46	30.80	37.82	2.91	35.46
Eucalyptus+ C.flexouses	6.53	0.38	5.11	18.46	1.14	15.30	25.72	1.46	24.11	31.46	2.21	28.87	35.05	2.39	30.12	35.55	2.78	34.01
Eucalyptus (pure)	5.71	0.32	4.60	16.17	0.94	13.62	22.42	1.16	19.47	27.56	1.85	22.31	31.21	2.08	27.54	32.89	2.37	29.83

	Poplar			Eucalyptus		
	N	P	K	N	P	K
CD at 5% for stand age(a)	0.812	0.816	0.831	0.749	0.942	0.712
CD at 5% for species mixture(b)	1.012	1.012	1.118	1.031	1.071	1.214
CD at 5% for interaction(axb)	2.234	2.149	2.349	2.142	2.246	2.546

Considering all the factors of root system together, the Poplar trees may be classified as shallow rooted because more than 75 percent of the total root biomass was located in 75 cm soil depth within 100 cm radial distance.

Table 5: Root Biomass (gm) of *Populus deltoids* trees under different age groups, radial distances, soil depths and root grades

Variables	Age of Populus deltoids (months)			
	24	36	48	60
Radial Distance(cm)				
0-50	950.0 (45.09)	2884.6 (45.52)	8685.6 (39.50)	11056.0 (38.98)
50-100	685.5 (32.51)	2039.4 (32.18)	9042.1 (41.12)	11302.7 (39.85)
100-150	472.5 (22.41)	1413.7 (22.31)	4259.5 (19.37)	6001.5 (21.16)
Soil Depth(cm)				
0-15 d1	1100.8 (52.20)	3303.8 (52.13)	14715.7 (66.93)	15447.2 (54.47)
15-45 d2	656.5 (31.13)	1960.9 (30.94)	5525.4 (25.13)	7781.9 (27.44)
45-75 d3	260.7 (12.36	795.8 (12.56)	1112.7 (5.08)	3086.4 (10.88)
75-105 d4	90.8 (4.31)	277.2 (4.37)	633.4 (2.88)	2044.7 (7.21)
Root Grades				
Fibrous g1	57.4 (2.72)	173.4 (2.74)	728.1 (3.31)	1079.6 (3.81)
Thin g2	195.5 (9.27)	567.1 (8.95)	2291.1 (10.42)	3030.2 (10.69)
Medium g3	416.0 (19.73)	1282.6 (20.24)	2466.1 (11.22)	3831.2 (13.51)
Thick g4	1439.9 (66.28)	4314.6 (66.08)	16501.9 (75.05)	20418.8 (71.99)
Total (gm/tree)	2108.8 (100)	6337.7 (100)	21987.2 (100)	28360.2 (100)

Poplar have well developed tap roots and is capable of surviving on deep and relatively dry sites. However, this tree species, besides its well developed tap roots,also have extensive lateral and sinker roots,that permit them to flourish on shallow soils and soil with fluctuating water tables. As evident from the results on root biomass the age of the trees had significant effect on the total root system of *Eucalyptus* trees. The total root biomass is also given in Table-6 , at various age groups in gm/tree.

Regarding the radial distribution of the roots, the results indicated that in all the age group of trees the total root biomass decreased continuously with increasing radial distance from the tree base at all the soil depths. The results indicated that as the age of trees increased, the radial span of roots also increases. Regarding, the vertical distribution of the roots of the *Eucalyptus*, the results indicated that the total root biomass decreased continuously with increasing soil depth at all the radial distances and under all the ages. According to Zohar (1985), concentration of most roots were reported at a depth of 40-80 cm in *Eucalyptus*.

Table – 6. Root Biomass (gm) of Eucalyptus trees under different age groups, radial distances, soil depths and root grades

Variables	Age of Eucalyptus (months)			
	24	36	48	60
Radial Distance(cm)				
0-50	881.2 (62.13)	3232.7 (62.74)	8635.8 (44.26)	10571.9 (43.13)
50-100	361.8 (25.51)	1245.5 (24.17)	6060.6 (31.06)	7649.7 (31.20)
100-150	175.3 (12.36)	674.6 (13.09)	4812.5 (24.67)	6289.0 (25.65)
Soil Depth(cm)				
0-15 d1	921.8 (64.99)	3171.7 (61.55)	8622.9 (44.20)	10946.4 (44.66)
15-45 d2	397.1 (28.00)	1396.5 (27.10)	5159.2 (26.45)	6362.0 (25.96)
45-75 d3	91.7 (6.47)	420.8 (8.17)	3483.5 (17.86)	4383.2 (17.88)
75-105 d4	7.7 (0.54)	163.8 (3.18)	2243.3 (11.49)	2819.0 (11.50)
Root Grades				
Fibrous g1	45.4 (3.20)	169.6 (3.29)	301.1 (1.54)	368.7 (1.50)
Thin g2	101.4 (7.15)	372.8 (7.29)	638.0 (3.27)	769.6 (3.13)
Medium g3	688.9 (48.57)	2556.7 (49.62)	3259.1 (16.70)	3887.7 (15.86)
Thick g4	582.6 (41.08)	2053.7 (39.86)	15310.7 (78.48)	19484.6 (79.49)
Total (gm/tree)	1418.3 (100)	5152.8 (100)	19508.9 (100)	24510.6 (100)
Values in paranthesis indicate the percentage of total root biomass				

CONCLUSION

This indicated that *Eucalyptus* has superficial root system. The results further indicated that the major part of the root system of juvenile age groups was made up of medium roots (0.5-1.5); while in old age groups the major part of the root system was made up of thick roots (>1.5cm). It is well known that the trees which develop strong tap roots are capable of penetrating the soil to greater depths for anchorage and moisture; so *Eucalyptus* survives well on relatively dry sites.

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Research Article

Study the phenology, growth and reproductive behavior of *Calendula officinalis*

Kusum Rani[1], UK Varshani[1], Mukesh Kumar[2]* and Amarjeet[2]
[1]*Department of Botany and Plant Physiology, CCS Haryana Agricultural University, Hisar, Haryana, India*
[2]*Regional Research Station, CCS Haryana Agricultural University, Bawal (Rewari), Haryana, India*
**Corresponding author e-mail: sabharwalmk@gmail.com*
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ABSTRACT
The experiment was conducted to study the phenology, growth, and reproductive behavior of Calendula officinalis under field conditions. Seeds were sown in the first week of December. In phenological studies, vegetative growth was undertaken up to March; flowering (anthesis) initiated simultaneously in the month of February and continued till mid-April; fruiting and seed maturation also occurred simultaneously from mid-April to early May and death/senescence was observed from early May onwards. Growth attributes viz., plant height, basal stem diameter, the number of leaves plant-1, leaf biomass, stem and branches biomass, flowers, and fruits biomass and root biomass studied increased with the advancement of growth stages (vegetative, flowering, and maturity stage) under field conditions. However, the root/ shoot ratio decreased with the advancement of the growth stage. Reproductive behavior such as number of flower heads plant-1, number of seeds head-1, seeds output (numbers per plant), seed yield (g/plant), germination of seeds produced, and reproductive capacity was observed as 51, 40.3, 2055.7, 6.1, 86.67, and 1783.02 at maturity stage in field conditions.
Keywords: *Calendula officinalis, growth, yield parameters, reproductive capacity*

INTRODUCTION
Calendula officinalis L. commonly known as pot marigold in English belongs to the family Asteraceae (Compositae). Its name comes from the Latin word (calend) meaning the first day of each month because this plant has a long flowering period. The plant is native to the Mediterranean zone, the Middle East, and Central Europe. This plant has been grown in European gardens since the 12th century. It is not only a springboard for monasteries and gardens but has an array of uses in drugs, foods, feed, beverages, dye, culinary, cosmetics, perfumery industries, and at ceremonial religious occasions (Kalvatchev et al., 1997), efficient pesticide (Martin, 2005). It is cultivated as an ornamental plant in countries viz., Iran, Palestine, Iraq, Saudi Arabia, Egypt, Libya, Tunisia, Algeria, Morocco, Canary Islands, Southern Spain Turkmenistan, Afghanistan, Pakistan, and Kashmir until its medicinal properties were known (Mozafariyan, 2003). Pot marigold is being grown as a medicinal drug in Germany, Australia, Czech, Austria, Switzerland, Hungary, Egypt, Syria, Eastern Europe, North America, India, etc. (Samsamsharit, 2003). It is an annual herb with simple leaves, bright yellow or orange daisy-like flowers that is used as a decorative plant in the horticultural industry (Duke et al., 2002).

The tincture and sap of its flowers are used locally to hasten the cure of injuries and to reduce swelling. Its sap is also used to reduce the body temperature, cure painful menstruation and cancer. The pot marigold flower has astringent, menstruation, anticonvulsant, energizing, antiseptic nourishing, sophomoric, diuretic, blood thinning and elimination of vomiting effects. It has uses in anemia, kidney problems, grip, mumps, chickenpox, measles, ulcer, jaundice, neurotic problems, acne pimples, skin disease, wounds, snow bites. Its flowers can be used to lower the cholesterol level of the blood or blood pressure because of dilation of surface vessels, relieving stomach ulcers and curing digestive system problems (Mohammad and Kashani, 2012). Research efforts are being made toward the utilization of such areas which have become unsuitable for raising conventional crops due to one or the other reasons that may be used for growing such plants depending upon their suitability to the prevailing environmental conditions. With the diversification of agriculture, medicinal and aromatic plants are gaining importance in the national scenario. The present

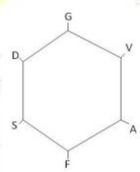
investigation was undertaken to enrich the scientific database regarding the morpho-physiology of *Calendula officinalis* under field conditions.

MATERIALS AND METHODS

The experimental site is situated at 29˚10′ North latitude and 75˚46′ East longitude at an elevation of 215.3 m above the mean sea level. This region has semi-arid climate with severely cold winter and hot dry summer. The average annual rainfall is about 420 mm, bulk of which is mostly received from mid June to mid September. There was no specific pattern of rainfall in winter season during which this investigation was carried out. The seeds were collected from the Botanical Garden, Department of Botany and Plant Physiology, CCS Haryana Agricultural University, Hisar in the month of May. Seeds were sown directly in field, Botanical Garden, CCS Haryana Agricultural University, Hisar.

PHYSIO-CHEMICAL PROPERTIES OF THE SOIL

Parameters	:Soil of field (Botanical Garden)
pH	:8.0
EC $_{1:2}$	:0.20 dSm^{-1}
Organic Carbon:	0.15 %
Available K_2O	: 375 kg/ha
Available P_2O_5	:20 kg/ha
Texture	:Sand



PHENOLOGY : Various life cycle events were expressed diagrammatically as :
G - Germination; V - Vegetative growth;
A -Anthesis; F - Fruiting;
S - Seed maturation; D-Death /senescence

GROWTH BEHAVIOUR **:** Plant height was measured with the help of meter scale from ground level to the tip of the apical shoots or flower of tallest shoot at the vegetative (75 DAS), flowering (105 DAS) and maturity stages (155 DAS). Average plant height was calculated and presented in centimeter (cm). Basal stem diameter was measured with the help of digital vernier caliper at two and half centimeter above the ground level and expressed in millimeter (mm). Numbers of leaves per replication were counted as leaves per plant basis.

Leaves, shoot portion (stem and branches except leaves and flower), flower and fruit portions of plants and roots of the plants were dried in an oven at 60±2˚C till the weight achieved and determined on digital electronic balance, and expressed in gram. Roots were washed thoroughly under running water to remove the adhering soil particles. Root and shoot portions were separated with the help of scissors for root shoot ratio.

REPRODUCTIVE BEHAVIOR: Total number of flowers was counted visually on all the experimental plants to observe number of flowers per plant. Fruiting heads were harvested after maturity and seeds were separated and then counted for number of seeds per head. The average seeds per flower head were multiplied by number of flower heads to calculate total number of seeds per plant. Seed collected at the time of maturity were air dried and germinated in petri dishes on moistened filter paper discs under laboratory conditions in the month of October, per cent seed germination was calculated. The criterion for seed germination was the emergence of radicle. Reproductive capacity was calculated with the help of formula suggested by Salisbury, 1942.

$$\text{Reproductive capacity} = \frac{\text{Av. seed output plant}^{-1} \text{ x Av. \% seed germination}}{100}$$

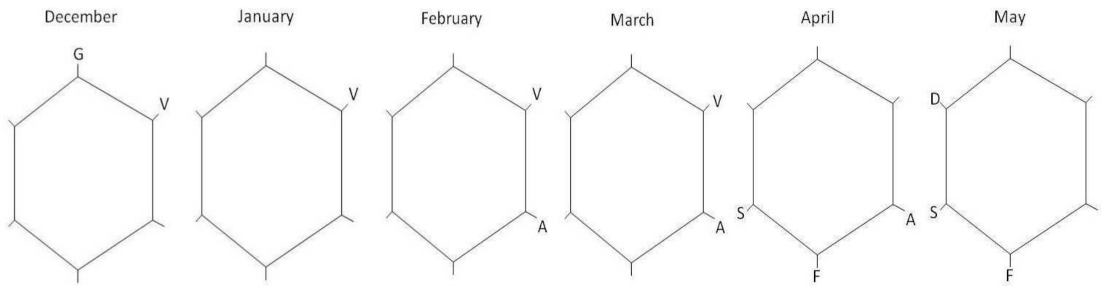
The data was analysed using randomized block design as suggested by Panse and Sukhatme, 1967.

RESULTS AND DISCUSSION

PHENOLOGY**:** The seeds of *Calendula officinalis* were sown in field conditions, germination completed within week, in the first week of December. It was followed by the vegetative growth up to March. The flowering (anthesis) initiated in the month of February and continued till mid April (Fig. 1). Fruiting and seed maturation occurred simultaneously from mid April to early May. Death / senescence was observed from early May onwards.

GROWTH ATTRIBUTES

Plant height of *Calendula officinalis* under field conditions increased with the aging of plants. A significant increase in plant height was recorded up to the flowering stage (Table 1), however, the maximum height of the plants (64.00 cm) was achieved at the maturity stage. The increase in basal diameter, however, was not significant beyond the flowering stage. Maximum basal stem diameter of 13.5 mm was found at the maturity stage. The number of leaves plant-1 increased significantly with the growth of plants and a maximum number of leaves (262.3) was recorded at the maturity stage. Plant height, basal stem diameter, and the number of leaves of calendula increased from vegetative stage to maturity stage increased. These parameters increased due to an increase in shoot biomass, leaf area, root biomass, which ultimately increases the uptake of nutrients and production of photosynthates for the overall growth of the plant. The results are in accordance with Kumar et al., 2006a, Kumar et al., 2006b, Kumar et al., 2007, and Kumar et al., 2014 in the marigold.



G=germination; V=vegetative growth; A=anthesis (flowering); F=fruiting; S=seed maturation; D=death/ senescence
Fig. 1: Phenological study of *Calendula officinalis* under field condition

GROWTH ATTRIBUTES

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An increase in leaf biomass (g plant-1) was recorded with the advancement of the growth stage. The increase in accumulation of food material and photosynthates may increase the growth attributes such as plant height, basal diameter, number of leaves, and leaf biomass. It reached up to 3.93 g plant-1. The increment in leaf biomass, however, was not significant beyond the flowering stage. Stem and branches biomass (g plant-1) continued to increase with the advancement of age and became 8.95 g plant-1 at the maturity stage.

The flower and fruit biomass (g plant-1) also increased from flowering to the maturity stage. It was a maximum (7.16 g plant-1) at the maturity stage. A significant increase in root biomass (g plant-1) was obtained from the vegetative to flowering stage and then reached a maximum (1.75 g plant-1) at the maturity stage. It means an increase in growth parameters directly increases the flower biomass of the plant. The root/ shoot ratio at the vegetative stage was 0.12. It decreased with the advancement of the growth stage. A significant decrease in root/ shoot ratio, however, was recorded up to the flowering stage. The minimum root/ shoot ratio of the plant (0.09) was recorded at the maturity stage. Leaf biomass, stem and branch biomass, flower and fruit biomass, and root biomass increased as the overall growth of the plants increased. The increases in these parameters are inter-correlated with each other. The increase in growth parameters directly proportionate to the increase in growth parameters (Kumar et al., 2007). As the overall growth of the plant enhanced the flowers and fruit biomass will also increase (Kumar et al., 2006b).

Table 1: Growth attributes of *Calendula officinalis* L. under field conditions

Growth parameters	Growth stage (GS) Vegetative Stage	Flowering Stage	Maturity Stage	CD ($P \leq 0.05$)
Plant height (cm)	07.83	60.33	64.00	04.93
Basal Stem diameter (mm)	06.33	12.67	13.50	02.16
Number of leaves plant^{-1}	018.0	239.0	262.3	011.5
Leaf biomass (g plant^{-1})	01.21	03.76	03.93	00.81
Stem and branches biomass (g plant^{-1})	00.17	06.29	08.95	00.23
Flowers and fruits biomass (g plant^{-1})	00.00	03.85	07.16	00.42
Root biomass (g plant^{-1})	00.16	01.32	01.75	00.13
Root/ Shoot ratio	00.12	00.10	00.09	0.02

REPRODUCTIVE BEHAVIOUR

The number of flower heads plant^{-1} in *Calendula officinalis* under field conditions significantly increased from 40.33 at the flowering stage to 51.00 at the maturity stage (Table 2).

Number of seeds head^{-1} has been recorded to 40.3±0.9. Seed output was 2055.7±46.8 number plant^{-1}. Seed yield was found to be 6.1±0.3 g plant^{-1}. The germinability of seeds under field conditions was observed to be 86.67± 0.35% [Table 2]. The average reproductive capacity was worked out to be 1783.02± 15.0 %.

Table 2: Reproductive behaviour of *Calendula officinalis* L. under field conditions

Parameters	Flowering stage	Maturity stage	CD ($P \leq 0.05$)
Number of flower heads plant^{-1}	40.33	51.00	01.54
Number of seeds head^{-1}	-	40.3±0.9*	-
Seed output (number plant^{-1})	-	2055.7±46.8*	-
Seed yield (g plant^{-1})	-	6.1±0.3*	-
Germination of seeds produced (%)	-	86.67±0.35*	-
Reproductive capacity	-	1783.02±15.0*	-

* Mean ±Standard Error

CONCLUSION

In plant phenology the vegetative growth stage was overlapped with anthesis, fruiting and seed maturation overlapped with flowering. Death/ senescence was observed from early May onwards. Growth attributes, flowers and fruits biomass (g plant^{-1}) and root biomass (g plant^{-1}) increased with the advancement of growth stage under field conditions. The root/ shoot ratio, however, decreased with the advancement of growth stage. Reproductive behaviour such as number of seeds head^{-1} (40.3±0.9), seeds output (2055.7±46.8 number plant^{-1}), seed yield (6.1±0.3 g plant^{-1}), germination of seeds produced (86.67±0.35%) and reproductive capacity (1783.02±15.0) were performed better under field conditions. Number of flower heads plant^{-1} was increased from flowering (40.33) to maturity stage (51.00).

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Research Article

Influence of different establishment method, varieties and nitrogen level on productivity and economics of rice

Pankaj Prashad Joshi*[1], Santosh Marahatta[1], Shrawan Kumar Sah[1] and Lal Prasad Amgain[2]
[1]Agriculture and Forestry University, Chitwan, Nepal
[2]Institute of Agriculture and Animal Science, Tribhuwan University, Nepal
**Corresponding author e-mail: ppjoshi@afu.edu.np*
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ABSTRACT
A field experiment was conducted to determine the productivity and economics of rice influenced by crop establishment methods, varieties and nitrogen levels on growth, phenology and yield of rice cultivars in the sub-tropical climate of Chitwan, Nepal. Three factors Strip-split plot experimental design using establishment methods (conservation and conventional agriculture) in vertical plots; varieties (hybrid Gorakhnath 509 and high yielding Sabitri) in horizontal plots and four nitrogen levels (0, 60, 120 and 180 kg N ha^{-1}) in sub-sub plots was laid out with three replications. The research result revealed that, grain yield of rice along with nitrogen use efficiencies, net return and B:C ratio was significantly higher in conservation agriculture than conventional agriculture. The higher grain yield in CA plots was because of higher number of effective tillers per square meter as compared to conventional agriculture. The grain yield of both hybrid and high yielding varieties were statistically similar whereas nitrogen level of 180 kg ha^{-1} produced the highest grain yield which was statistically similar to 120 kg ha^{-1} N but significantly higher than 60 kg ha^{-1} N. Higher N application increased the effective tillers per square meter and number of grains per panicle which resulted in higher grain yield. Net return and B:C ratio were higher at 120 and 180 kg ha^{-1} N applied plots. Thus for sustainable rice production, conservation agriculture with high yielding variety and nitrogen level of 120 kg ha^{-1} are best.
Keywords: Conservation agriculture, conventional agriculture, nitrogen levels, effective tillers

INTRODUCTION
Rice rank as a first crop in terms of area coverage and productivity in Nepal. It occupies 56.42% of cultivated land with a productivity of 3.50 t ha-1 (MOAD, 2076) and constitutes 13.85 % of agricultural gross domestic product (MOF Economic Survey, 2016) overcoming more than 50% of Nepalese calorie requirement (Basnet, 2014).
In rice planting, two methods are common i.e. conventional and conservation tillage. The conventional method is prevalent in Nepal which is done through transplanting in the puddled fields. In the conventional method, puddling of the soil is the main operation that benefits by reducing water percolation losses, controlling weeds, facilitating easy seedling establishment, and creating anaerobic conditions to enhance nutrient availability (Sanchez, 1973). However, it encounters several problems such as labor-intensive, high water requirement for puddling, and negative impact on soil physical, chemical, and microbial properties which increase the cost of cultivation with a potential loss in farm income. Repeated puddling develop hardpan in the subsoil below the puddled layer (Giri, 1988) which restricts the growth and productivity of succeeding wheat crop (Sharma, Ladha & Bhusan, 2003). Moreover, methane emission is higher in transplanted rice fields than in direct seeding (Kumar & Ladha, 2011). Also, nitrogen leaching is more severe in flooded rice, heavy application of nitrogen in flooded rice causes emerging problems of deficiency of micronutrients such as zinc and secondary nutrients such as sulfur (Sakal, 1977). Further, intensive tillage systems result in decreased soil organic matter and biodiversity (Biamah et al., 2000). As only 52.08% of the total cultivated area is irrigated in Nepal (MOAC, 2016) farmers are forced to monsoon dependent transplanting operations in Nepal

cause the shift in cropping calendar and impact on yield.

On contrary, conservation agriculture (CA) has emerged as a promising technique in rice cultivation through decreasing the water demand by omitting the puddling operation and conserving the soil. Conservation agriculture is based on the principles of resource conservation, through minimum tillage, optimum residue retention, and proper crop rotation (Sayre & Hobbs, 2004). CA practices increase water storage, reduce water loss and erosion, improve crop yield and water productivity, and labor use (Xiaobin, 2006), increase soil organic matter (Rasmussen, 1999), increase carbon sequestration (Uri et al., 1999), and produce yield equivalent to or higher than those under conventional farming (Karunatilake, Vanes & Schindelbeck, 2000; Guerif, Richard, Durr, Machet, Recous & Roger-Estrade, 2001). However, a major problem that limits the CA are Apart high weed infestation (Joshi, Kumar, Lal, Nepalia, Gautam & Vyas, 2013), poor seed germination, and reduced early seedling growth (Qi, Nie, Liu, Peng, Shah, Huang, Cui & Sun, 2012) and high nitrogen loss through denitrification, volatilization, leaching, and runoff as compared to conventional agriculture (Kumar & Ladha, 2011; Davidson, 1991).

Apart from the establishment methods, nitrogen has a significant role in the productivity of rice. Only a part of applied nitrogen is used by plants and the remaining residual is accumulated in soil or lost as runoff (Khan & Mohammad, 2014). The synchronization between crop demand and nitrogen supply is the most important aspect of increasing nitrogen fertilizer use efficiency, high yields, and reduced nitrogen losses. Levels of nitrogen required especially vary among the varieties either hybrid, improved or local. A real-time N management requires periodic assessment of nitrogen status in standing crops and applying the optimum nitrogen dose to reduce its loss. Adhikari (2006) stated that low nitrogen use efficiency in the ineffective splitting of N application including the use of nitrogen in excess of the requirement is one of the various factors responsible for lower rice production (Adhikari, 2006).

Nitrogen demand differs with inbred and hybrid varieties. Hybrid technology allows farmers to obtain 15-30% more rice than conventional high-yielding varieties (Siddiq, 1993; Virmani, Mao & Hardy, 2003). Viramani (1996) reported that hybrid rice required different strategies for N management to maximize the expression of their yield advantage. The country's target is to achieve over 5 million tons of rice production by the year 2020 to be food sufficient (Joshy, 1997). The labor problem is increasing and forming being uneconomic. Effective nitrogen management and improved package of practices play an important role in the increasing response to added nitrogen and thereby improving the grain yield of high-yielding varieties including hybrids. Considering these facts experiment was conducted to be acquainted with the level of nitrogen best suitable for the rice cultivars under different cultivation practices.

MATERIALS AND METHODS

The experiment was carried out at the agronomy block of Agriculture and Forestry University Rampur, Chitwan in sandy loam soil with a moderately acidic pH of 5.93. Total nitrogen and soil available potassium was found to be lower (0.15% and 116.85 kg ha^{-1}) in surface soil profile but soil available phosphorous was found to be of medium (27.45 kg ha^{-1}) and most of all parameters were found decreasing with increasing profile depth up to 1m. Weather data regarding minimum and maximum temperature, relative humidity, and rainfall were collected from the National Climatic Observatory of National Maize Research Program, Rampur, Chitwan. Three-factor Strip-split design was used as an experimental design with establishment method as a horizontal factor, varieties as a vertical factor, and nitrogen levels as subplot factor. Establishment methods include conservation agriculture (zero tillage with residue) and conventional tillage (P-TPR), varieties include hybrid Gorakhnath 509 and improved Sabitri, and nitrogen levels were 0, 60, 120, and 180 kg N ha-1. For the conventional method, nursery raising was done and transplanting was done with 21 days old seedlings. 2-3 seedlings per hill with hill spacing of 20cm row to row and plant to plant was maintained during transplanting. Urea, diammonium phosphate, muriate of potash, and single super phosphate were used as sources of fertilizer. As per the government recommendation, 30:30 PK kg ha-1 fertilizer was used except the nitrogen which was used as per the treatment. The full dose of Phosphorous and potassium were broadcasted as basal dose and nitrogen was applied at three splits: half at basal, one fourth at active tillering, and one fourth at the panicle initiation stage. In CA, rice was sown continuously in mechanically drawn rows spaced 20cm apart. Fertilizer was applied as a side dressing in the basal application and broadcasted at the top dressing. Observation on yield and yield attributes were recorded and analyzed through MSTAT-C software. The experiment was carried out at the agronomy block of Agriculture and Forestry University Rampur, Chitwan in sandy loam soil with a moderately acidic pH of 5.93. Total nitrogen and soil available potassium was found to be lower (0.15% and 116.85 kg ha-1) in surface soil profile but soil available phosphorous was found to be of medium (27.45 kg ha-1) and most of all parameters were found

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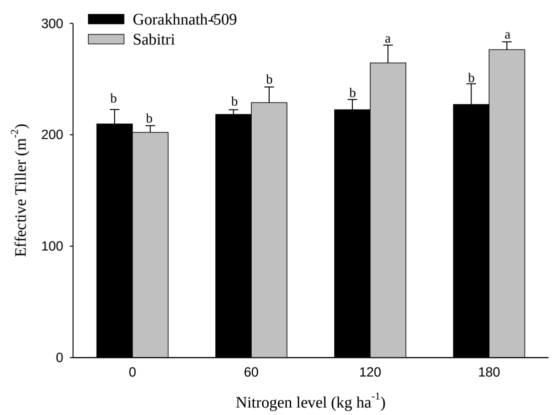
RESULTS AND DISCUSSION

Yield attributing characters

In the experiment, effective tillers were significantly differed due to nitrogen levels and establishment methods only. Effective tillers per meter were found significantly higher in conservation agriculture (261.10) than conventional agriculture (201.30). The result was in line with Hobbs, Singh, Giri, Lauren & Duxbury (2002). This was due to the close spacing causing a higher plant population (Patil et al., 2007) which increases the mother plant causing less effect due to tiller mortality. Fageria (2014) reported that in the aerobic condition the effective tillers in the main culm are important than other secondary tillers. In conservation agriculture seeds are shown continuously in rows resulting in more number of the main culm which is limiting in TPR due to wider spacing. An increase in nitrogen level increased the effective tillers per meter. Effective tillers per meter in 180 kg N ha^{-1} (251.80) was at par with 120 kg N ha-1 (243.50) but was significantly higher than 60 kg N ha-1. The lowest effective tillers were observed in nitrogen a control plot (205.90) which was similar to 60kg N ha-1. Thakur and Singh (1987) also reported significantly higher effective tillers per square meter and spikelets per panicle in higher nitrogen levels.

Interaction of varieties and nitrogen levels significantly influenced the effective tillers (Figure 1). Gorkhanath-509 have statistically similar effective tillers per square meter for all nitrogen levels whereas Sabitri showed significantly higher tillers in 180 kg N ha^{-1} as compared to 60 and 0 kg N ha^{-1} and was at par with 120 kg N ha^{-1}.

Figure 1: Effective tillers (m^{-2}) of rice as influenced by interaction between varieties and nitrogen level in 2015 at AFU, Rampur, Chitwan, Nepal



Note: Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5% level of significance

Grains per panicle were found higher in conventional agriculture (137.70) than conservation agriculture (122.80). Gorakhnath-509 had statistically higher grains per panicle (158.90) as compared to Sabitri (101.60). Grains per panicle was found highest in 120 kg N ha^{-1} (136.10) which was significantly at par with 180 (135.00) and 60 kg N ha^{-1} (129.60). Nitrogen control was found to have lowest grain yield (120.10). Similar results was obtained by Maqsood (1998). In grain filling stage, nitrogen contributes to grains (Swain & Jagpat, 2010) which helps to decrease the sterility and increase grains per panicle.

Thousand grain weight was found significantly higher in conventional agriculture (17.80 g) than conservation agriculture (17.67 g). In direct seeded rice, increase effective tillers per square meter increases intra plant competition which decrease the size of grains. Similarly, Sabitri (20.65 g) have higher thousand grain weight than Gorakhnath-509 (14.82 g). It resulted due to fine grains of Gorakhanath-509 than Sabitri. The significant difference between varieties was due to their genotypic character as Gorakhnath 509 is a fine grain cultivar whereas Sabitri is coarse grain as compared to Gorakhnath 509. Significant difference was not observed in thousand grain weight due to nitrogen

levels. Similar, result was obtained by Patil, et al (2001).

Table 1: Influence of establishment methods, varieties and nitrogen levels on Yield attributes of rice during monsoon season at Rampur, Chitwan, Nepal, 2015

Treatment	Effective tillers (m^{-2})	Grains per panicle	Thousand grain weight (g)
Establishment method			
CA	261.10^{a}	122.80^{b}	17.67^{b}
Con A	201.30^{b}	137.70^{a}	17.80^{a}
SEm (±)	9.27	1.58	0.02
LSD (=0.05)	56.40	9.62	0.102
Varieties			
Gorakhnath-509	219.40	158.90^{a}	14.82^{b}
Sabitri	242.90	101.60^{b}	20.65^{a}
SEm (±)	8.85	5.82	0.26
LSD (=0.05)	Ns	35.44	1.592
Nitrogen levels (kg ha^{-1})			
0	205.90^{c}	120.10^{b}	17.98
60	223.50^{bc}	129.60^{ab}	17.77
120	343.40^{ab}	136.10^{a}	17.64
180	251.80^{a}	135.00^{a}	17.55
SEm (±)	7.24	4.14	0.23
LSD (=0.05)	21.13	12.08	Ns
CV, %	10.80	11.00	4.40
Grand mean	231.20	130.20	17.74

Note: CA, Conservation agriculture; ConA, conventional agriculture; ns, non-significance. Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5% level of significance

Yield

The grain yield of conservation agriculture (4766 kg ha^{-1}) was statistically higher than conventional agriculture (4106 kg ha^{-1}) (Table 2). It was due to the sum effect of leaf area index and effective tillers. CA increases yield by improving soil fertility through soil and water conservation and sequestering organic carbon (Holland, 2004; Govaerts et al., 2007). Varieties didn't have any significant influence on yield. It was due to the similar yield potential of both varieties. In the case of nitrogen levels, the grain yield at 180 kg N ha^{-1} was statistically similar with the grain yield (4769 kg ha^{-1}) at 120 kg N ha^{-1} but significantly higher than grain yield at 60 kg N ha^{-1} (4308kg ha^{-1}) and 0 kg N ha^{-1} (3686 kg ha^{-1}). Manzoor et al (2006) also reported similar results. The numbers of tillers and spikelets are increased by increased nitrogen content (Matsushima, 1976) which ultimately increases the yield.

The straw yield was significantly higher in conventional agriculture (5648 kg ha ha^{-1}) as compared to conventional agriculture (4487 kg ha ha^{-1}). Similarly, in the case of variety, Sabitri had a significantly higher (5683 kg ha ha^{-1}) straw yield as compared to Gorakhnath-509 (4451 kg ha^{-1}). The average straw yield was found to be 5067 kg ha^{-1}. In the case of nitrogen, straw yield at 180 kg N ha^{-1} (5896 kg ha^{-1}) was significantly at par with 120 kg N ha-1 (5792 kg ha^{-1}) which was statistically higher than 0 (4041 kg ha^{-1}) and 60 kg N ha^{-1} (5540 kg ha^{-1}). Straw yield results from the total biomass which increased due to higher effective tillers per square meter in CA. Fageria (2014) stated that higher nitrogen application helps in protein metabolism and ultimately carbohydrate metabolism in the latter stages of growth which might be the cause of higher total above-ground biomass.

Table 2: Influence of establishment methods, varieties and nitrogen levels on grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) of rice during monsoon season at Rampur, Chitwan, Nepal, 2015

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Establishment methods		
CA	4766.00^{a}	5648.00^{a}
ConA	4106.00^{b}	4487.00^{b}
SEm (±)	35.60	62.7
LSD (=0.05)	216.50	381.5
Varieties		
Gorakhnath	4438.00	4451.00^{b}
Sabitri	4433.00	5683.00^{a}
SEm (±)	172.80	183.70
LSD (=0.05)	ns	1117.50
Nitrogen levels (kg ha^{-1})		
0	3686.00^{c}	4041.00^{b}
60	4308.00^{b}	4540.00^{b}
120	4769.00^{a}	5792.00^{a}
180	4980.00^{a}	5896.00^{a}
SEm (±)	91.00	268.40
LSD (=0.05)	265.70	783.30
CV, %	7.10	18.30
Grand mean	4436.00	5067.00

Note: CA, Conservation agriculture; ConA, conventional agriculture; ns, non-significance. Treatments means followed by common letter (s) are not significantly different among each other based on DMRT at 5% level of significance

Economic Analysis

The total cost of production in conservation agriculture was lower (80.94 thousand NRs ha^{-1}) than that of conventional tillage (84.10 thousand NRs ha^{-1}). In comparison between varieties, the cost was 23.33% higher in Gorakhnath 509 than in Sabitri. The higher cost of Gorakhnath 509 was due to the higher cost of hybrid seeds than improved. In the case of nitrogen level, it was highest in 0 kg N ha^{-1} (86.13 thousand NRs ha^{-1}) as followed by 180 (83.92 thousand NRs ha^{-1}), 120 (81.68 thousand NRs ha^{-1}), and 60 kg N ha ha^{-1} (80.94 thousand NRs ha^{-1}).

Gross return was significantly higher in conservation agriculture by 17% as compared to conventional tillage. Nitrogen level showed increasing gross return with increasing the dose of nitrogen. The highest gross return was obtained at 180 kg N ha^{-1} (143.47 thousand NRs ha 1) which was statistically at par with 120 kg N ha^{-1} (137.01 thousand NRs ha^{-1}) but significantly higher than 60 kg N ha^{-1} (122.94 thousand NRs ha^{-1}) and

nitrogen omitted plots (106.42 thousand NRs ha^{-1}). The net return also showed a similar trend to the gross return. It was found significantly higher in conservation agriculture (56.76 thousand NRs ha^{-1}) as compared to conventional tillage (32.23 thousand NRs ha^{-1}). Net return increased with an increase in the dose of nitrogen due to increased production. The highest net return was obtained at 180 kg N ha^{-1} (60.35 thousand NRs ha^{-1}) which was statistically at par with 120 kg N ha-1 (55.33 thousand NRs ha^{-1}) but significantly higher than 60 kg N ha^{-1} (42.00 thousand NRs ha^{-1}) and nitrogen omitted plots (20.29 thousand NRs ha^{-1}).

Table 3: Influence of establishment methods, varieties and nitrogen levels on Cost of cultivation (thousand NRs. ha^{-1}), gross returns (thousand NRs. ha^{-1}), net returns (thousand NRs. ha^{-1}) and B:C ratio of rice during monsoon season at Rampur, Chitwan, Nepal, 2015

Treatments	Total production cost ('000)	Gross Returns ('000)	Net Returns ('000)	B:C ratio
Establishment methods				
CA	80.94	137.69^{a}	56.76^{a}	1.73^{a}
ConA	84.10	117.22^{b}	32.23^{b}	1.40^{b}
SEm(±)		0.89	0.89	0.01
LSD (=0.05)		5.42	5.44	0.06
Varieties				
Gorakhnath	91.97	121.19	29.22	1.32^{b}
Sabitri	73.97	133.74	59.77	1.81^{a}
SEm(±)		5.10	5.10	0.06
LSD (=0.05)		ns	ns	0.35
Nitrogen levels (kg ha^{-1})				
0	86.13	106.42^{c}	20.29^{c}	1.25^{c}
60	80.94	122.94^{b}	42.00^{c}	1.55^{b}
120	81.68	137.01^{a}	55.33^{a}	1.72^{a}
180	83.12	143.47^{a}	60.35^{a}	1.76^{a}
SEm(±)		3.61	3.61	0.04
LSD (=0.05)		10.54	10.54	0.13
CV, %		12.75	44.49	1.57
Grand mean		9.80	28.10	9.80

B:C ratio was significantly influenced by all treatments (establishment methods, varieties and nitrogen levels) (table 3). B:C was found to be significantly higher in conservation agriculture (1.73) as compared to conventional tillage (1.40). In case of varieties, Gorakhnath 509 had lower (1.32) B:C than Sabitri (1.81). Nitrogen level showed increasing B:C with increasing the dose of nitrogen. Highest net return was obtained at 180 kg N ha^{-1} (1.76) which was statistically at par with 120 kg N ha^{-1} (1.72) but significantly higher than 60 kg N ha^{-1} (1.55) and nitrogen omitted plots (1.25).

Kumar & Ladha (2011) conducted economic analysis of of rice establishment practices and concluded that US $ 9– 125 ha^{-1} reductions on the cost of production in ZT-DSR compared with puddled-TPR. IRRI (2009) also recorded higher net return in ZT-DSR in many experiment conducted in different states of India. These cost reductions and increased income were largely due to either reduced labor cost or tillage cost or both under DSR systems. The higher cost of cultivation in N omitted plots may be due to the result of need of high amount of SSP.

CONCLUSION

Rice in humid subtropics can be successfully grown under conservation agriculture and have a chance to harvest more yield, improving profit along with saving the cost of cultivation. Improve variety Sabitri yielded similar to the popular hybrid. Hybrid requires more nitrogen as compared to improve Sabitri and the requirement is even more under conservation agriculture. Application of 120 kg N ha^{-1} was seemed to have better yielding and economic return as at par with 180 kg N ha^{-1}.

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Research Article

Yield and economic advantage of direct seeded rice: empirical evidence from Nepal

Santosh Marahatta

Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal
**Corresponding author e-mail: smarahatta@afu.edu.np*
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ABSTRACT
Puddled transplanted rice (TPR) has been gradually replaced by direct-seeded rice (DSR) because of its low labor requirements and less cost of cultivation. Whether and how DSR can be as productive and profitable as TPR has received widespread attention. Thus a comprehensive analysis was made to quantify the effects of direct seeding on rice yield and profitability under different tillage, residues, varieties, and nitrogen management options. The results revealed that, overall, the yield of DSR was 2.4% lower than that of TPR due to a significant reduction in the number of grains per panicle and a significant increment of sterility percentage. However, the yield loss of DSR relative to TPR was highly variable depending on different tillage and residue management options, ranging from yield advantage of +6.0% to yield penalty of 16.0%. The yield gap between CT-DSR and TPR could be narrowed by not incorporating the residues while more yield could be obtained with the residues retention on the ZT-DSR. Among the different forms of the DSR, ZT with residue retention and CT without residue retention were better in terms of profitability. Adoption of improved or hybrid varieties played the less important role in yield gain and loss under DSR. With respect to nitrogen levels, the yield penalty was eliminated by the higher nitrogen application (>120 kg N ha-1) resulted in the yield advantage of 6.6% for the DSR as compared to the puddled TPR. In conclusion, DSR could produce comparable yields and more profits to TPR, but special attention should be given to optimizing management practices to improve DSR yield performance and narrow down the yield gap. Therefore, there is an urgent need to test, verify, and scale-out the DSR technologies across the different agro-ecologies of Nepal through a farmer-centered partnership among the international institutions, public and private sectors of Nepal.
Keywords: direct-seeded, puddled transplanted, rice yield advantage, economic advantage of DSR

INTRODUCTION
Rice is the most important staple food crop in Nepal both in terms of area (1.46 million ha) and production (5.55 million tons) (MOF, 2020). Rice provides 50% of the total calorie requirement to the Nepalese population (Kharel et al., 2018) and contributes 13.85% to the agriculture gross development product (AGDP) (MOF, 2017). It is grown throughout all agro-ecological regions from terai plains to the high hills up to 3050 maslincluding valleys and foothills (MoAD, 2015). Rice is the major cereal crop of the terai and inner terai (occupy 67.87% of total area). The national average yield of rice (3.69 t ha-1, based on three years average ending in 2019/20) (MOF, 2020)is far below the attainable yield of >8.0 t ha-1, indicating the huge yield gaps. Current rice production of 4.46 million ton is not sufficient to meet the current national demand of 5.26 million ton and by 2030 the rice production must be increased by 1.03 million ton which is equivalent to an overall increase of 22.59% in the coming next 11 years (CBS, 2014; MOF, 2017; Prasad et al., 2011; Tripathi et al., 2018). As the possibility of expanding the area under crops in the future is very limited, the required extra production has to come through an increase in productivity. Under the declining water, labor and increasing cost of production meeting such targets are challenging. Thus the new rice cultivation technology must be developed to address the scarce resources of labor and water by reducing the simultaneously while maintaining the yield potential (Yuan et al., 2017).
Rice is often grown by transplant seedlings into puddled soil. Puddling advantages rice by reducing water percolation losses, managing weeds, facilitating

simple seed plant establishment, and making anaerobic conditions to boost nutrient convenience (Kaur and Singh, 2017). But, continual puddling adversely affects soil physical properties by destroying soil aggregates, reducing porousness in subterranean layers, and forming hard-pans at shallow depths (Aggarwal et al., 1995; Sharma et al., 2003) and the chemical properties reducing the soil organic matter and biodiversity (Biamah et al., 2000). These adverse effects would ultimately hamper the succeeding non-rice crop(Hobbs and Gupta, 2000; Tripathi et al., 2005). Crop establishment consists of four basic following steps: (a) nursery bed preparation, (b) seedling raising, (c) seedling uprooting, and (d) transplanting seedlings into the main field (Xu et al., 2019). The puddled transplanting requires large quantities of the water (1200 liters) to produce 1 kg of rough rice (Morisonet al., 2008) whereas, the per capita water availability decreased significantly till now and predicted to decrease by about 28% by 2050(Bhatt and Kukal, 2015).These practices are highly labor- and water-intensive and becoming less profitable, as these resources are being increasingly scarce. Further puddling and transplanting delay rice transplanting up to three weeks as it demands a large volume of scarce water resources, which further delays the sowing of succeeding non-rice crops in the system. Direct seeded rice (DSR) has emerged as a suitable and sustainable alternative technology to deal with water- and labor-shortages (Sun et al., 2015). Commonly in direct-seeded rice (DSR) pre-germinated or dry rice seeds are broadcasted/drilled into the conventionally tilled field that saved large amounts of scarce resources like water and labor (Ladha et al., 2003).There are three principal methods of DSR: dry seeding (sowing dry seeds into dry soil), wet seeding (sowing pre-germinated seeds on wet puddle soils), and water seeding (seeds sown into standing water) (Akhgari and Kaviani, 2011). In recent years, DSR cultivation has been increasingly adopted by farmers in many traditional TPR regions in south Asia (Sun et al., 2015), however, the area of direct seeding is limited to upland rice culture. Due to the efforts of research activities by the International Rice Research Institute (IRRI), International Maize and Wheat Research center (CIMMYT), Nepal Agriculture Research Council (NARC), Agriculture and Forestry University (AFU), Institute of Agriculture and Animal Science (IAAS) and international and national non-governmental organizations (I/NGOs) on the transformation on cultivation practices of rice has stimulated the governments' concerns.

To determine the yields and economic advantages of DSR, series of field experiments at Agronomy Research Block of AFU and the Institute of IAAShavebeen conducted to determine yield differences between DSR and TPR at Rampur, Chitwan, Nepal. Some studies have indicated that the DSR yieldsare equivalent, or even higher than the TPR yield and should, therefore, be widely promoted to farmers because of high net economic returns (Bhushan *et al*., 2007; Liu *et al*., 2014). However, this viewpoint has been challenged by several different studies, that observed apparent yield losses (Chen *et al*., 2017). These conflicting results may be due to variations in ecological and management factors, i.e. soil and climatic conditions, tillage method, weed control, residue management, and nitrogen input(Xu *et al*., 2019). Due to these uncertainties, a comprehensive analysis to synthesize the results of previous studies at AFU and IAAS to evaluate the yield, and economics between DSR and TPR. However, due to some extent of management practices and annual variations on the weather factors, the yield performance of DSR and TPR is still ambiguous.

MATERIALS AND METHODS

Site description

Ten different field experiments were done in the Agronomy Research Block of AFU and IAAS at Rampur, Chitwan located in the central Terai region of Nepal (27^{o}40′ N latitude, 84^{o}19′ Elongitude, and 228 masl) during the rainy season of 2010-2019. The experimental site lies in the subtropical humid climate belt of Nepal with the predominant of sandy loam soil. The area has a sub-humid type of weather condition with cool winter, hot summer, and a distinct rainy season with an annual rainfall of about 2000 mm. The weather data during the cropping seasons were recorded from the metrological station of the National Maize Research Program (NMRP), Rampur, Chitwan (Figure 1).

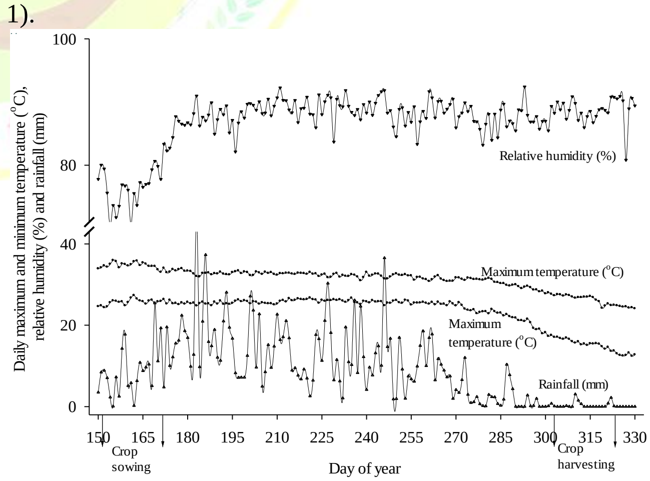


Figure 1. Daily maximum and minimum temperature (^{o}C), relative humidity (%), and rainfall (mm) of the experimental site (average of ten years, 2010-2019) during the experimental period

On average, the mean maximum temperature was 32^{o}C and minimum temperature was 24^{o}C, relative humidity

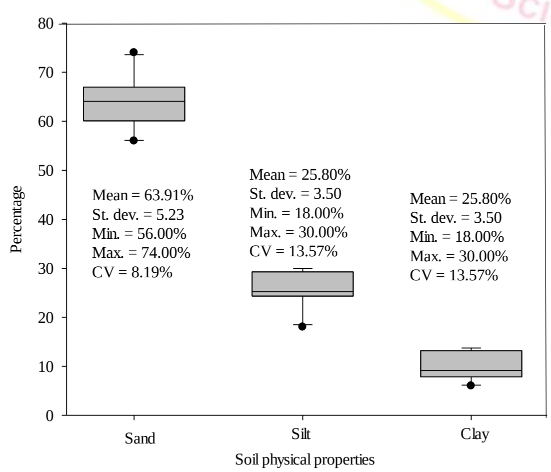
was 88% and total rainfall of 1502 mm was received during the rice-growing season of the experiments (Figure 1 and Table 1).

Table 1. Statistics of weather parameters of the experimental site during rice growing period of the different experiments (average of seven years)

Statistics	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Total rainfall (mm)	Number of rainy days
Average	31.86	24.21	88.03	1502.11	81.00
St.dev.	2.94	4.08	7.62	360.76	21.56
Variance	8.62	16.62	58.12	501.02	501.02
CV	9.22	16.84	8.66	220.54	220.54
CA	-1.16	-1.90	-0.77	-0.26	2.88
Curtose	1.58	4.27	1.27	-0.68	8.62
Minimum	20.75	6.45	48.81	890.40	67.00
First quartile	30.50	23.20	83.37	1274.05	71.25
Median	32.30	25.25	88.00	1546.40	73.00
Third quartile	33.95	26.70	94.61	1773.83	78.75
Maximum	38.70	31.15	100.00	1982.20	144.00
Range	17.95	24.70	51.19	1091.80	77.00

Note:St.dev.,standard deviation; CV, coefficient of variation; CA, coefficient of asymmetry

In each experiment, just before the experimentation composite soil samples were collected using a tube augerform the depth of 0-20 cm. The initial soil physical and chemical properties varied among the trail's fields (Figure 2). Soil pH, the most important chemical property that affects the availability of mineral nutrients, varied from 5.20 to 6.51. The variation on clay was higher than the silt and sand content. The soil carbon and total nitrogen varied from 1.09 to 2.60 and 0.09-0.16 percent, respectively. The variation on the available phosphorus and potassium was higher than the other soil properties.



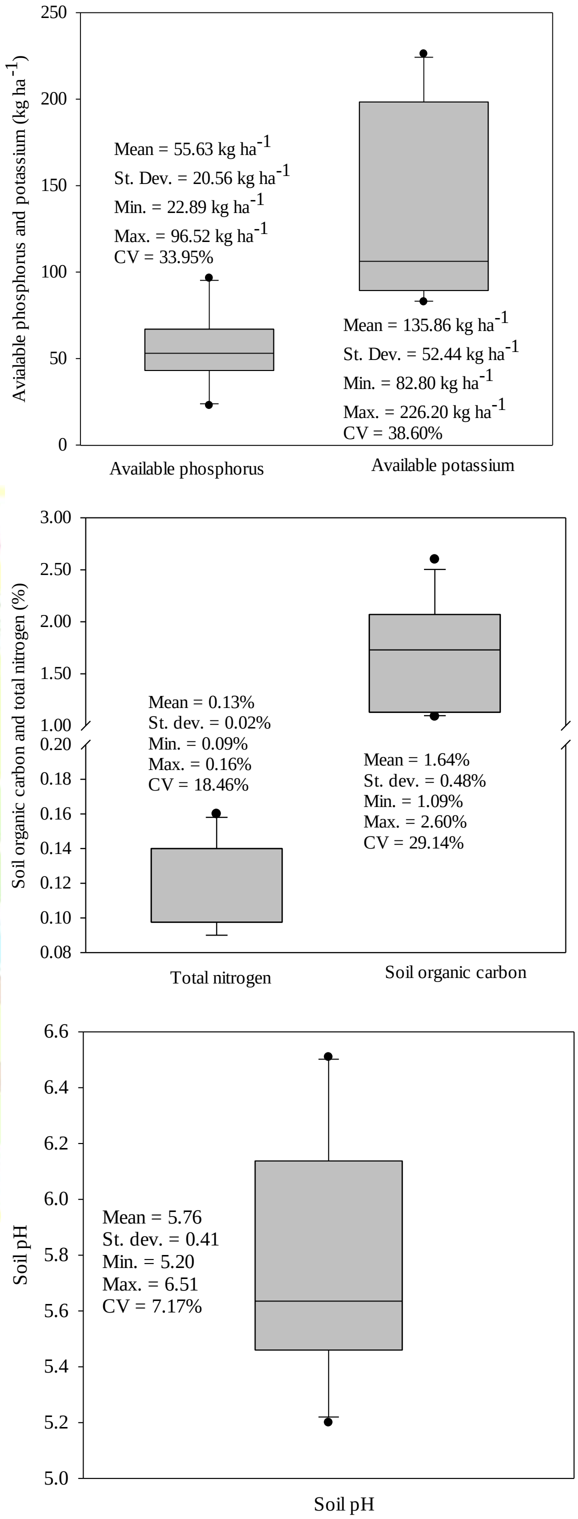


Figure 2. Initial soil properties of the experimental site (average of eleven experiments) at Rampur, Chitwan, Nepalalparasi, Nepal, 2010-2019

Note: St.dev.,standard deviation; Min, minimum; Max, maximum; CV, coefficient of variation

Experimental treatments, design and crop management

To assess the yield and economic performance of DSR over puddled TPR, a series of experiments were conducted in the Agronomy Research Block of AFU and IAAS, which are described as follows:

Experiment 1 (2010-18th June to 7th November): Split-split design was used with establishment methods (i.e. Puddled-TPR, Puddled-system of rice intensification, and dry-DSR) as themain plot factor, varieties (Sabitri, Loktantra, and Radha 4) as sub-plot factor with three replication. In DSR plots, rice seeds were sown continuously in mechanically drawn rows spaced 20cm apart with the seed rate of 45 kg ha^{-1} while for the puddled-TPR, 21 days old 2-3 seedlings planted per hill with hill spacing of 20 cm x 20 cm, and for the puddled-SRI, 14 days old 1 seedlings planted per hill with hill spacing of 25 cm x 25 cm. The full dose of phosphorous (30 kg P_2O_5 ha^{-1}), potassium (30 kg P_2O_5 ha^{-1}), zinc (20 kg $ZnSO_4$ ha^{-1}),and half dose of nitrogen (50 kg N ha^{-1}) was applied as basal dose and nitrogen was applied at three splits: half at basal, one fourth at active tillering, and one fourth at the panicle initiation stage.

Experiment 2 and 3 (2011: 1st July to 5th November and 2012: 10th July to 15th November): A randomized complete block design was used to test different types of rice establishment methods and residue management includes, CT-dry DSR, puddled –TPR, bed planting with residue retention, bed planting without residue retention, ZT-DSR with residue retention, and ZT-DSR without residue retention with three replication and experiment was conducted for two years. In CT-dry DSR plots and ZT-DSR plots, rice seeds were sown continuously in mechanically drawn rows spaced 20 cm apart with the seed rate of 30 kg ha^{-1} while for the puddled-TPR, 28days old 2-3 seedlings planted per hill with hill spacing of 20 cm x 20 cm. An improved rice variety, Sabitri was used in experiments. The full dose of phosphorous (40 kg P_2O_5 ha^{-1}), and potassium (40 kg P_2O_5 ha^{-1}) was applied as basal dose, and nitrogen (100 kg ha^{-1}) was applied at three splits: half at basal, one fourth at active tillering, and one fourth at the panicle initiation stage.

Experiment 4and 5(2011: 2nd July to November 8th and 2012: 7th July to 11th November): Three-factor strip-split design was used with establishment methods (i.e. zero tillage (ZT) with residue-DSR – ZT-wheat – dibbled mungbean and puddled-TPR without residue - CT-wheat) as a horizontal factor, varieties (hybrid Gorakhnath 509 and improved Sabitri) as vertical factor and nitrogen levels (0, 60, 120 and 180 kg N ha^{-1}) as subplot factor with three replication for the two years. In DSR plots, rice seeds were sown continuously in mechanically drawn rows spaced 20 cm apart with the seed rate of 40 kg ha^{-1} while for the puddled-TPR, 26days old 2-3 seedlings planted per hill with hill spacing of 20 cm x 20 cm. The full dose of phosphorous (50 kg P_2O_5 ha^{-1}), and potassium (40 kg P_2O_5 ha^{-1}) was applied as basal dose and nitrogen was applied at three splits: half at basal, one fourth at active tillering, and one fourth at the panicle initiation stage.

Experiment 6and 7(2011: 10th June to 7-9thNovember and 2012:11th June to 5-8th November): Strip-split design was used with establishment methods (i.e. ZT-DSR with the residue of maize, and puddled-TPR without residue) as a horizontal factor, nutrient management practices (130:60:30 kg N, P_2O_5 and K_2O ha^{-1}; and 60: 30:0 kg N, P_2O_5 and K_2O ha^{-1}) as a vertical factor, and weed management practices (two-manual weeding/hand pulling and chemical management, i.e. Pendimethalin @ 1 kg a.i. ha^{-1} for DSR and Butachlor@1 kg a.i. ha^{-1} for DSR as the pre-emergence application) as the sub-sub plot with three replication for two years. The variety used in the experiment was Sabitri. In DSR plots, rice seeds were sown continuously in mechanically drawn rows spaced 20 cm apart with the seed rate of 40 kg ha^{-1} while for the puddled and unpuddled-TPR, 21-24days old 2-3 seedlings planted per hill with hill spacing of 20 cm x 20 cm. based on the nature of treatments, fertilizers were applied. The full dose of phosphorous (30 kg P_2O_5 ha^{-1}), potassium (30 kg P_2O_5 ha^{-1}), and zinc (25 kg $ZnSO_4$ ha^{-1}) was applied as basal dose and nitrogen was applied at three splits: half at basal, one fourth at active tillering, and one fourth at the panicle initiation stage.

Experiment 8 (2014-8th June to 15th October): Strip-split design was used with establishment methods (i.e. CT-DSR, puddled-TPR, and unpuddled-TPR) as a horizontal factor, nutrient management practices (100% recommended NPK (100:30:30 kg N, P_2O_5 and K_2O ha^{-1}; leaf color chart (LCC) based N management + recommended P and K; farmers fertility management practices (49:35:0 kg N, P_2O_5 and K_2O ha^{-1}; 150% of recommended NPK; 0 N + recommended P and K; 0 P + recommended N and K; and 0 K + recommended N and K) as a vertical factor with three replication. In DSR plots, rice seeds were sown continuously in mechanically drawn rows spaced 20 cm apart with the seed rate of 50 kg ha^{-1} while for the puddled and unpuddled-TPR, 21 days old 2-3 seedlings planted per hill with hill spacing of 20 cm x 20 cm. based on the nature of treatments, fertilizers were applied. The full dose of phosphorous (30 kg P_2O_5 ha^{-1}), potassium (30 kg P_2O_5 ha^{-1}), and zinc (25 kg $ZnSO_4$ ha^{-1}) was applied as basal dose and nitrogen was applied at three splits: half at basal, one fourth at active tillering, and one fourth at the panicle initiation stage. In the case of LCC based nitrogen management, 25 kg N ha^{-1} was applied as basal and top dressing of nitrogen through the LCC

reading (reading was taken from 20 days after sowing for CT-DSR and 14 days after transplanting up to flowering) at the critical value (≤4) at 20 kg N ha^{-1}. Nitrogen amount of 35 kg N ha^{-1} was applied as basal and 14 kg N ha^{-1} top-dressed at the tillering stage.

Experiment 9(2015: 16th June to 17th November):Three-factor strip-split design was used with establishment methods (i.e. zero tillage with residue-DSR and puddled-TPR) as a horizontal factor, varieties (hybrid Gorakhnath 509 and improved Sabitri) as vertical factor and nitrogen levels (0, 60, 120 and 180 kg N ha^{-1}) as subplot factor with three replication. In DSR plots, rice seeds were sown continuously in mechanically drawn rows spaced 20cm apart with the seed rate of 45 kg ha^{-1} while for the puddled-TPR, 21 days old 2-3 seedlings planted per hill with hill spacing of 20cm x 20 cm. The full dose of phosphorous (30 kg P_2O_5 ha^{-1}), potassium (30 kg P_2O_5 ha^{-1})zinc (25 kg $ZnSO_4$ ha^{-1}) wasapplied as basal dose and nitrogen was applied at three splits: half at basal, one fourth at active tillering, and one fourth at the panicle initiation stage.

Experiment 10 (2016: 22ndJune to 13thNovember): Three-factor strip-split design was used with establishment methods (i.e. zero tillage -DSR and puddled-TPR) as a horizontal factor, residue management (residue kept and residue removed) as a vertical factor, and nitrogen levels (50, and 100 kg N ha^{-1}) as subplot factor with three replication. The variety used in the experiment was Ramdhan, an improved variety.In DSR plots, rice seeds were sown continuously in mechanically drawn rows spaced 20cm apart with the seed rate of 50 kg ha^{-1} while for the puddled-TPR, 30 days old 2-3 seedlings planted per hill with hill spacing of 20 cm x 20 cm. Pendimethalin was sprayed on the next day after sowing at the rate of 1 kg a.i. ha^{-1}. P_2O_5 and K_2O at the rate of 30:30 kg ha^{-1} and 1/3rdN was applied at the basal dose and remaining 1/3rdN at the active tillering stage and remaining N 1/3rdat the panicle initiation stage. Two hand weeding was done at 20 days after sowing (DAS) and 40 DAS.

Experiment 11 (2018: 15th June to 29th October): Three-factor split-split design with three replications which included two cropping system (rice-wheat and rice-maize) as main plot treatments, two establishment methods (ZT-DSR and puddled-TPR) as subplots, and four nutrient management practices (100% recommended dose of fertilizer (150: 45:45kg N, P_2O_5 and K_2O ha^{-1}), Residue retention of previous crops, i.e. wheat and maize (5 t ha^{-1}) + 75% RDF, nutrient expert dose (140:56:53 kg N, P_2O_5 and K_2O ha^{-1}), brown/green manuring + 75% RDF) as sub-sub plot treatments. Rice seed was directly sown at the seed rate of 45 kg ha^{-1}in the no-till field for ZT-DSR and transplanting of seedlingsof 30 days for puddled-TPR. Hybrid variety US-312 was used. The nutrient expert dose was determined using the Nutrient Expert Beta Version prepared by the International Plant Nutrition Institute (IPNI). The *Sesbania* seeds @ 60 kg ha^{-1} were sown in the field with rice and knocked down by spraying 2, 4-D and plot maintained as the brown manuring for direct-seeded rice and while for green manuring, *Sesbania* seeds @ 60 kg ha^{-1} were sown in the field 30 days before transplanting and incorporating immediately before the transplanting of rice.

Sampling and measurements

Grain yield was obtained from the net plot area of 12-20 m^{2}in the center of each plot, avoiding plot borders at harvestable maturity and from the same area straw yield, and harvest index was calculated. Grain yield, calculated to take account of row spacing, is reported in t ha^{-1} adjusted to the standard moisture content of 14%. The sampled straw used to determine the moisture percentage. Plant samples were dried at 65^{o}C for 72 hours.Additionally for rice plant parameters number of effective tillers per square meter, the number of grains per panicle, sterility percentage, and thousand grains weight were also collected. From the one or two quadrate of 1 m^2 number of panicle bearing tillers were recorded. Twenty panicles were randomly selected from each plot to count the average number of grains per panicle and sterility percentage. After threshing, seeds were cleaned and weighed. A sample of 250 grains was weighed from each replicate to derive thousand-grain weights and recalculate for a 14% moisture basis. Seed moisture content mass was measured using a Farmcomp Grain moisture tester (Wile 55).

The total variable cost was calculated by adding up the cost of seed, fertilizers, herbicides, machinery, human labor, and irrigation water. Human labor for tillage, seeding, irrigation, fertilizer and pesticide application, weeding, harvesting, and threshing of different treatments were recorded. The price of human labor, machinery used, seeds, pesticides, grain, and straw was collected through a market survey in each experiment. Machinery cost was based on the hiring of machines and the cost of irrigation water was calculated based on the duration of irrigation and rate per unit area. Gross return was calculated by adding the revenue from grain and straw. The straw yield on a dry-weight basis was used in the calculation. The netreturn was calculated by deducting the total variable cost of cultivation from the gross return. The B:C ratio was calculated by dividing gross return with the total variable cost of cultivation.

Data analysis

The paired wise comparison was made to evaluate the performance of DSR and puddled-TPR by using the paired t-test. To observe the effect of different management factors such as residue management, nitrogen management, and varieties, general categories

were maintained such as the residue retention of any amount was regarded as the residue retained treatments, nitrogen application lower than <60 kg ha^{-1} was categorized at the lower dose, 100-120 kg N ha^{-1} as the recommended dose and >130 as the higher dose, and the all improved varieties of any varietal duration was categorized as the improves and another category was the hybrids.

RESULTS AND DISCUSSION

Across all observations, DSR yield was only 2.4% lower than the yield of puddled transplanted rice (Table 2 and Figure 3). In an all unweighted analysis, the number of effective tillers per square meter showed a positive and significant response to the DSR whereas the number of grains per panicle was significantly reduced the sterility percentage was significantly increased. There is no significant difference in the thousand-grain weight between the DSR and puddled TPR with a slightly negative response to the DSR (Table 2 and Figure 3). The straw yield was significantly higher in DSR as compared to the puddled TPR. The lower grain yield and higher straw yield results in a significantly lower harvest index in the case of DSR.

DSR yields were lower than the puddled TPR in most of the cases (Table 2 and Figure 4). Among the different forms of DSR, 4.6%yield was decreased under CT-DSR without residues and 7.1% under CT-DSR with residue retention of the previous crops. The yield penalty (by 16.6%) was further increased in the case of ZT-DSR without residues but considerably increased the yield (by 5.4%) of ZT-DSR with residue retention as compared to puddled TPR. In all forms of the DSR, effective tillers per square meter were significantly higher than the puddled TPR whereas just reverse for the number of grains per panicle. DSR under ZT with residue retention responded positively for thousand grains weight which consequently resulted in yield gain whereas ZT DSR without residue retention grieved highest yield penalty because of reduction in thousand grains weight and significant increment in sterility percentage.The more yield loss in residue retention over no residue was due tosignificant increment in sterility percentage.

The establishment of rice under different tillage systems proved that rice can be successfully grown under ZT-DSR and proved to be more suitable alternative of conventional method of puddled TPR. Overall, it is not surprising with slightly lower yield of DSR than the puddled-TPR (Table 2 and Figure 3), but due to more benefits and low cost of cultivation, DSR is more advantageous (Figure 3B, 4B, 4C, and 4D), which is why DSR is also regarded as a labour- and water-saving rice production technique. This was in contrast with previous studies because diversities of studies were compiled in the present analysis. Farooq et al. (2006a, 2006b) and Farooq et al. (2009) grain yield in DSR is comparatively less than TPR. Sharma et al. (2004), Singh et al. (2001), and Tripathi et al.(2005) also reported lower grain yield of rice under DSR whereas Gathala et al. (2013) and Timsina et al. (2010) reported the higher yield while Hossain et al. (2020) reported that similar grain yield under ZT-DSR as compared to conventional puddled TPR. Experiments were conducted at farmers' fields to study the effect of the ZT system on the growth and yield of rice and observed that the grain yield of rice under ZT was similar to the puddled TPR (Reddy et al., 2005). The CT-DSR had a similar grain yield as the ZT-DSR plots after 4 years of cropping(Bhattacharyya et al., 2008) but the ZT practice had lower cultivation costs. The significantly same grain yield was recorded with ZT-DSR with residue retention and puddled TPR. However, Gathala et al. (2011) observed a 9-10% higher yield under ZT combined with residue mulch compared to the conventional tillage and ZT without crop residue. Higher rice yield under residue retention may be attributed to improvement in soil physical conditions (Singh et al., 2016) resulting in better soil moisture and nutrient availability (Yadvinder-Singh et al., 2004), and higher weed suppression through providing a physical barrier on the surface (Schuster et al., 2019). But the incorporation of residues is disadvantageous as it increased the immobilization of inorganic nitrogen and its adverse effect due to nitrogen deficiency might be the cause of lower yield under residues retention on the CT-DSR. Thus proper fertilizer management practices should be formulated to overcome these issues of nitrogen immobilization due to the incorporation of crop residues.

The direct-seeded rice had more number of effective tillers per square meter (Figure 3A) which was likely attributed to higher population density than the transplanted rice.(Saharawat *et al*., 2010) reported that number of effective tillers was numerically (9 per cent) higher in DSR as compared to the puddled TPR. The lower yield of DSR was mainly due to fewer number of grains per panicle (Figure 3A). But there was a compensation relationship between the number of effective tillers per square meter and the number of the grains per panicle, thus there was no severe yield loss under DSR. Differences in thousand grain weight were not significant between transplanted and direct-seeded rice. These findings indicate the existence of several yield compensation mechanisms enabling lowland rice to respond to various microclimatic conditions associated with different methods of crop establishment.

Table 2. Comparison of yield and yield component between the direct-seeded rice to puddled-transplanted rice across a wide range of management and environmental conditions

Establishment methods	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Effect tillers m^{-2}	Grains per panicle	Thousand grain weight (g)	Sterility (%)
DSR#	4.14	5.61	40.46	298.87	121.76	20.16	13.38
Pu-TPR	4.24	5.20	42.99	246.41	138.21	20.30	12.04
Mean diff.	-0.10	0.41	-2.54	52.46	-16.44	-0.14	1.34
No. of pair	150	150	150	150	150	150	150
SEm (±)	0.08	0.09	0.44	7.26	2.32	0.12	0.40
t-value	-1.26	4.52	-5.78	7.23	-7.09	-1.23	3.33
Probability	0.21	0.00	0.00	0.00	0.00	0.22	0.00
CT-DSR	3.97	5.77	38.72	263.66	107.37	21.67	15.20
Pu-TPR	4.16	5.60	39.69	217.23	129.65	21.73	14.43
Mean diff.	-0.18	0.18	-0.97	46.43	-22.28	-0.06	0.77
No. of pair	38.00	38.00	38.00	38.00	38.00	38.00	38.00
SEm (±)	0.20	0.19	0.84	11.82	6.21	0.27	0.79
t-value	-0.94	0.95	-1.15	3.93	-3.59	-0.22	0.97
Probability	0.35	0.35	0.26	0.00	0.00	0.82	0.34
CT-DSR + R	4.18	5.49	41.02	270.78	129.81	18.55	17.98
Pu-TPR	4.50	5.56	42.34	223.34	153.46	18.76	15.11
Mean diff.	-0.32	-0.07	-1.32	47.44	-23.66	-0.21	2.87
No. of pair	32	32	32	32	32	32	32
SEm (±)	0.14	0.14	0.65	10.54	4.29	0.30	0.87
t-value	-2.23	-0.51	-2.01	4.50	-5.52	-0.70	3.31
Probability	0.03	0.62	0.05	0.00	0.00	0.49	0.00
ZT-DSR	3.77	5.17	41.44	246.21	100.05	20.63	12.74
Pu-TPR	4.52	5.06	45.16	237.13	123.43	21.57	8.76
Mean diff.	-0.75	0.11	-3.72	9.08	-23.38	-0.94	3.98
No. of pair	16	16	16	16	16	16	16
SEm (±)	0.23	0.21	1.18	8.85	4.38	0.18	1.22
t-value	-3.25	0.51	-3.15	1.03	-5.34	-5.27	3.26
Probability	0.01	0.62	0.01	0.32	0.00	0.00	0.01
ZT-DSR + R	4.32	5.68	40.96	346.99	131.71	19.94	10.17
Pu-TPR	4.10	4.83	44.75	277.58	139.35	19.90	9.91
Mean diff.	0.22	0.86	-3.79	69.40	-7.64	0.04	0.26
No. of pair	64	64	64	64	64	64	64
SEm (±)	0.11	0.14	0.75	14.10	2.92	0.15	0.58
t-value	1.95	6.07	-5.04	4.92	-2.61	0.28	0.45
Probability	0.06	0.00	0.00	0.00	0.01	0.78	0.66

Note: #, includes all form of DSR; CT-DSR, conventional tillage-direct seeded rice; Pu-TPR, Puddled transplanted rice; + R, with residue; ZT-DSR, Zero tillage direct-seeded rice; Mean diff., mean difference; SEm (±), standard error of the mean of the mean difference series

The direct-seeded rice had more number of effective tillers per square meter (Figure 3A) which was likely attributed to higher population density than the transplanted rice.(Saharawat *et al*., 2010) reported that number of effective tillers was numerically (9 per cent) higher in DSR as compared to the puddled TPR. The lower yield of DSR was mainly due to fewer number of grains per panicle (Figure 3A). But there was a compensation relationship between the number of effective tillers per square meter and the number of the grains per panicle, thus there was no severe yield loss under DSR. Differences in thousand grain weight were not significant between transplanted and direct-seeded rice. These findings indicate the existence of several yield compensation mechanisms enabling lowland rice to respond to various microclimatic conditions associated with different methods of crop establishment.

DSR yields were lower than TPR yields in most cases, however, the yield gapbetween DSR and TPR could be narrowed by appropriate management (Figure 4A). Compared toTPR, the yield in DSR was only 0.29% lower in improved varieties, whereas the yield penalty was 1.35% in hybrids. In the case of CT-DSR, the

3.97% yield loss could be minimized to 2.44%, when the residues were not applied. Contrastingly, the yield loss of 16.03% could be minimized and 5.96% more yield could be achieved, when the residues were retained for ZT-DSR.In case of no nitrogen and high nitrogen level yield advantage (12.29 and 6.64%, respectively) of DSR compared to puddled TPR whereas at the low and recommended nitrogen yield loss were 1.57 and 8.36% respectively.

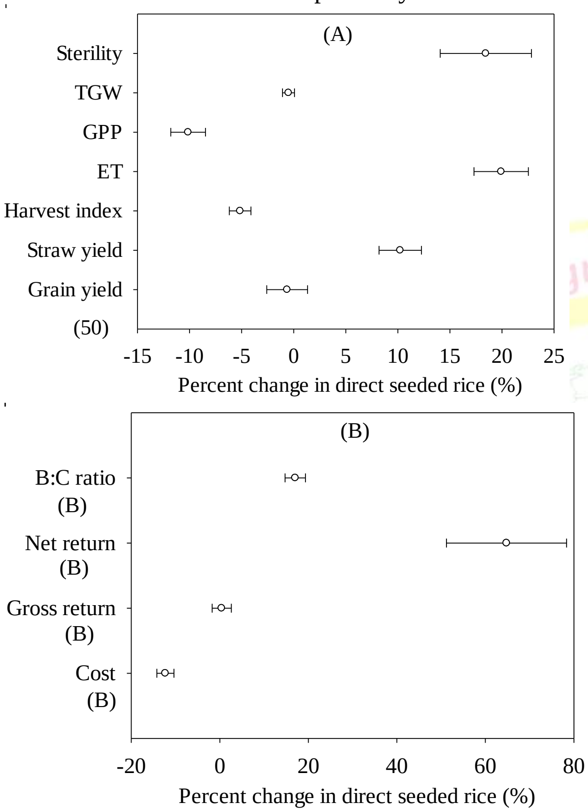
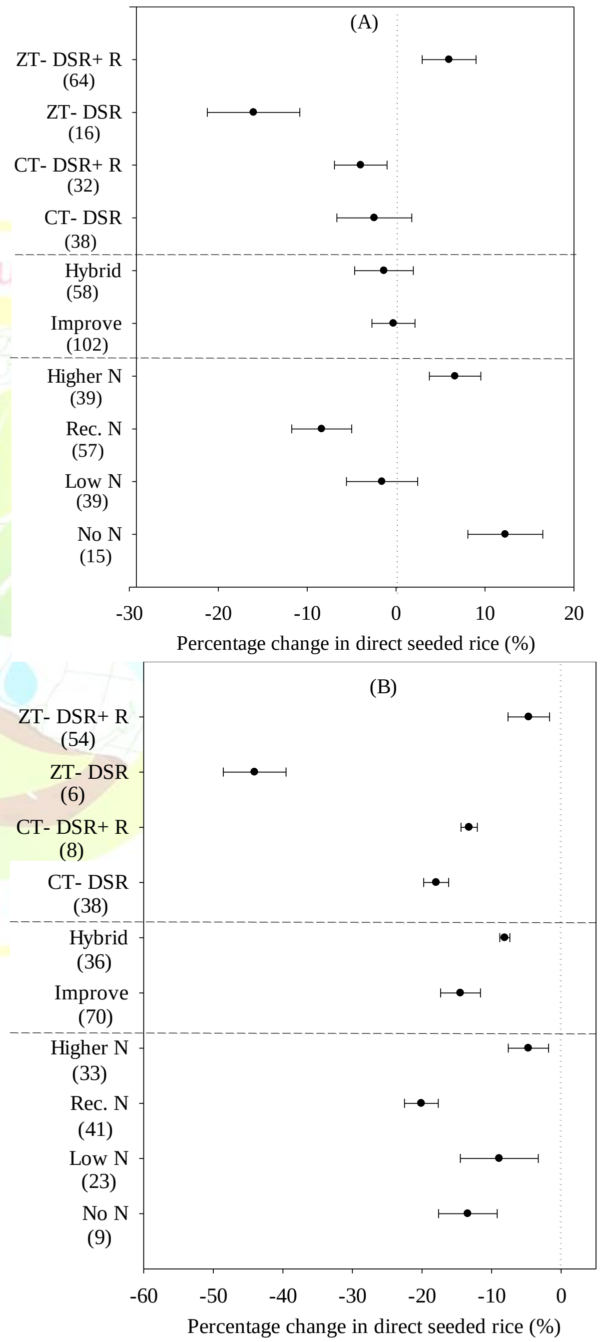


Figure 3. Change in (A) yield and yield attributes, and (B) economics of production comparing direct-seeded rice to puddled transplanted rice across a wide range of management conditions. The number of paired observations included in each dataset is presented in parenthesis.

For DSR, due to the high seed cost for hybrid, improved variety was slightly better in terms of economic benefits. Percent benefits on nitrogen omission were the highest for DSR than puddled TPR as compared to nitrogen applied situation, but the gross and net return was 21.8 and 43.4% higher in nitrogen applied treatments as compared to nitrogen omission in DSR. Despite the yield loss under DSR, the cost of cultivation was drastically reduced and more profit was obtained (Figure 3). The high cost of residues and more yield penalty for CT-DSR with residue retention resulted in the reduction of net return whereas the B:C ratio was even lower than the puddled TPR. Though the highest yield loss was calculated for ZT-DSR without residue retention, the highest reduction in the cost of cultivation made it comparable to the ZT-DSR in terms of net profit and higher B:C ratio than the CT-DSR with residue retention. Among the different forms of the DSR, ZT with residue retention and CT without residue retention was better in terms of profitability. ZT-DSR with residue retention compensate the cost of the residue by yield improvement.



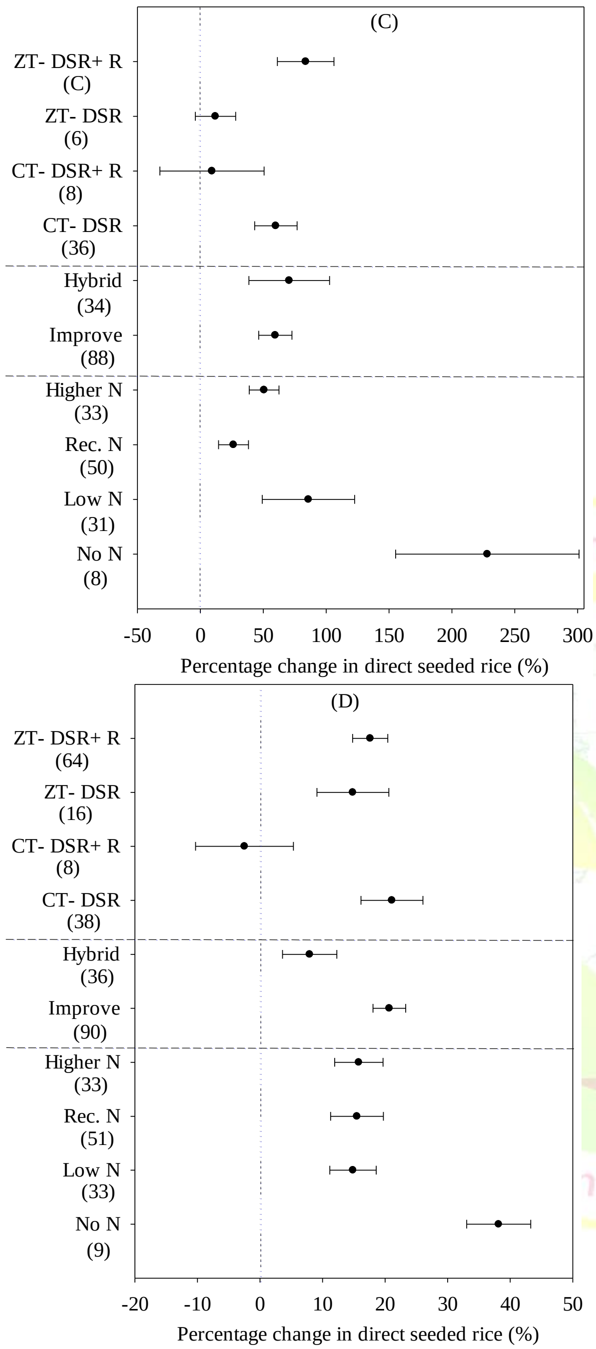


Figure 4. Influence of different establishment methods and residues, varieties, and nitrogen input on the (A) yield change, (B) cost of cultivation, (C) net return, and (D) B:C ratio of direct-seeded rice relative to transplanted rice. The number of paired observations included in each dataset is presented in parenthesis

CONCLUSIONS

This analysis concluded that DSR yield was slightly lower than that of TPR. The lower yield of DSR was due to reduction in number of grains per panicle and higher sterility. However, the yield gapbetween CT-DSR and puddled TPR could be narrowed without incorporating the residues whereas more yield could be obtained with the residues retention on the ZT-DSR. Under the nitrogen omission and higher nitrogen application, DSR was more productive as compared to puddled TPR. Among the different forms of the DSR, ZT with residue retention and CT without residue retention were better in terms of profitability. ZT-DSR with residue retention compensate the cost of the residue by yield improvement along with the improvement of the soil qualities in long run.

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Research Article

Effect of rice establishment methods and nutrient management practices on subsequent wheat crop grown under different establishment methods and nutrient management practices at Rampur, Chitwan, Nepal

Puspa Raj Dulal*and Santosh Marahatta
Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal
**Corresponding author e-mail: pusparajdulal@gmail.com*
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ABSTRACT
A field experiment was conducted to evaluate the effect of land management practices and residual effect of nutrient management practices of rice on the performance of subsequent wheat crop in the rice-wheat cropping system in Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal during June 2018-March 2019. The experiment was executed in a split-plot, included two establishment methods viz. (i) conventional tilled dry direct-seeded rice followed by (*fb*) zero tillage wheat (CT-DDSR *fb* ZT) (ii) puddled transplanted rice followed by conventional tillage wheat (Pu-TPR *fb* CT) as main plot treatments, and four nutrient management practices: (i) 100% recommended dose (100% RDF; 150:45:45 and 80:60:40 kg N, P_2O_5, and K_2O ha^{-1} respectively for rice and wheat), (ii) Residue retention @ 5 t ha^{-1} of wheat on rice *fb* residue of rice on wheat + 75% RDF of each crop (RR +75%RDF), (iii) Nutrient expert (NE) dose (140:56:53; 140:60:45 kg N, P_2O_5, and K_2O ha^{-1} for rice and wheat respectively), (iv) Brown/green manuring of *Sesbania* in rice *fb* rice residue @ 3.5 t ha^{-1} in wheat +75% RDF of each crop (BM/GM *fb* R+75% RDF) as subplot treatments with three replications. The variety of wheat 'Bijay' was sown @120 kg ha^{-1} with spacing 20 cm × continuous. The data on phenology, yield, yield attributes, and economics were recorded and analyzed by R studio. The study revealed that none of the yield attributes and yield of wheat were significantly influenced by the establishment methods. Significantly more effective tillers (281.94 m^{-2}) and grains per spike (44.48) and higher straw yield (5.95 t ha^{-1}) were recorded under NE dose. The grain yield of wheat was 21% and 16% more under NE dose and BM/GM *fb* R+75% RDF respectively compared to 100% RDF. CT-DDSR *fb* ZT wheat had slightly less net returns (NRs. 4523 ha^{-1}) than Pu-TPR *fb* CT-wheat. NE dose was the most profitable. Hence, rice establishment methods were indifferent but NE dose was the best nutrient management practice for better production and profitability for the wheat in the rice-wheat system.
Keywords: Nutrient Expert, residue, zero tillage wheat

INTRODUCTION
Wheat (*Triticum aestivum* L.) is the dominant crop of the cereal-based cropping systems, produced in 167 million ha with a yield of 3.53 t ha-1 globally and the Asian region alone contributes 43.50% to global wheat production (FAOSTAT, 2017). It is the food for more than a billion people and is crucial in ensuring food security and livelihood in Indo-Gangetic Plain (IGP) (Kumar et al., 2018). Wheat covers 1657 thousand ha of the total cultivable land of Nepal and covers 56.86% of plains of Nepal (MoALD, 2018) out of which more than 60% of the area is unirrigated (Pandey et al., 2017) Despite the higher potential yield (Amgain & Timsina, 2004) (4.4 t ha-1) of wheat in Nepal, the national average yield has been confined to 2.78 t ha-1 (MoF, 2018) which created a huge yield gap in the nation. To meet the demand, Nepalese agriculture has now been import-driven and imported wheat worth NRs. 5.07 billion during the fiscal year 2018/19 (The rising Nepal, 2019). So, the adoption of suitable agronomic management along with new technological innovation can be the only option to sustain this situation.

In the Nepalese rice-wheat cropping system, the popular crop establishment method includes the transplantation of 20-25 days old rice seedlings in the puddled field while wheat is established (in rice residue removed fields) by broadcasting/drilling seed after conventional tillage and planking operations (Bhatt,

Kukal, Busari, Arora, & Yadav, 2016). The continuous practice of conventional tillage in most areas has led to degradation in soil property i.e. increase in the soil bulk density (Zamir et al., 2013), reduction in soil porosity, infiltration, and moisture retention capacity (Moraru & Rusu, 2013), and the faster decomposition of residues and quicker mineralization of the nutrients (Thomas et al. (2007) which increases the nutrient loss leaving the soil infertile in long run. In addition to the detrimental effects of traditional rice production practices on soil properties, the conventional wheat planting system involves repeated dry tillage to prepare the field which also leads to further delay in wheat seeding by almost a week compared to zero tillage planting (Kumar et al., 2014). This intensive tillage leads to a long turn round period (Tripathi et al., 2005). The hydrology of wheat is different from the rice crop and hence the rice establishment method has a great impact on its yield. The reduced or zero tillage restore the soil aeration, porosity and discard the hardpan formation making suitable field conditions for the plantation of subsequent aerobic crops i.e wheat with a 9% yield increment in the field followed after DSR than TPR (Kumar & Ladha, 2011).

Crop residue is the above-ground part of the plants that remained after the grain is harvested and is the important plant nutrient source that can replenish the extensively mined nutrients due to intensive cropping. Typical amounts of nutrients in rice straw at harvest are 5-8 kg N, 0.7-1.2 kg P_2O_5, 12-17 kg K_2O, 0.5-1 kg S, 3-4 kg Ca, 1-3 kg Mg, and 40-70 kg Si per ton on a dry weight basis. South Dakota State University data shows that wheat stover contains approximately 4.54 kg N, 3 1.36kg P_2O_5, 14.06 kg K_2O, and 0.91 kg S per ton (iGrow, 2014) and hence, the decomposition of such applied crop residues in the field can reduce the amount of fertilizers to be applied. Green manuring and brown manuring also have a positive impact on soil organic matter. In addition, it acts as surface mulch thereby conserving the soil moisture and improving the soil physicochemical properties, and reduce the problems of soil crusting resulting in faster germination of succeeding wheat crop (Samant, 2017). Nutrient Expert (NE) is computer-based nutrient decision support software based on site-specific nutrient management (SSNM) principles and enables farm advisors to develop fertilizer recommendations tailored to a specific field or growing environment (IPNI, 2017). It is being popular among the farm managers for supplying the nutrient to the crop through the right source and in the right dose in line with the crop demand.

The yield stability of wheat grown after the rice has been a popular issue and the appropriate agronomic management practices including the methods of crop establishment and suitable nutrient management practices have always been the focal area of global research but a solid conclusion is yet to be derived. Hence, the current study was carried out.

MATERIALS AND METHODS

Site description

The experiment was conducted at the research block of Agronomy Farm of Agriculture and Forestry University (AFU), Rampur, Chitwan district of Bagamati Province of Nepal (27˚40' N and 84˚23' E and 256 masl) from June 2018 to May 2019. The soil in the experimental field was sandy loam with pH with slightly acidic to neutral with medium to low OM and nitrogen content, high phosphorus and medium potassium content according to the standard rating of Directorate of Soil Management, Ministry of Agriculture Development, Government of Nepal, Kathmandu, Nepal (Table 1).

Table 1. Physico-chemical properties of soil of the experimental site during 2018-19

Properties	Average Content	Rating			Methods and References (Estefan, Sommer & Ryan,2014)
Physical properties					Hydrometer
Sand (%)	63.10	Sandy loam			
Silt (%)	28.00				
Clay (%)	8.90				
Chemical properties					
	0-15 cm	Rating	15-30 cm	Rating	Methods and References
Soil pH	6.40	Acidic	6.5	Neutral	Beckman Glass Electrode pH meter
Soil organic matter (%)	3.20	Medium	1.79	Low	Walkey and Black
Total nitrogen (%)	0.16	Medium	0.09	Low	Micro Kjeldhal Distillation
Available phosphorus (kg ha $^{-1}$)	85.03	High	130.97	High	Modified Olsen's method
Available potassium (kg ha $^{-1}$)	214.61	Medium	138.65	Medium	Ammonium Acetate method

The experimental site lies in the subtropical humid climate belt of Nepal. The area has sub-humid type of weather condition with cool winter, hot summer, and distinct rainy season with annual rainfall of about 2000 mm. The weather data during the cropping seasons was recorded from the metrological station of the National Maize Research Program (NMRP), Rampur, Chitwan (Figure 1).

Experimental design and treatments

The experiment was done by using a split-plot design, with two factors i.e. two establishment methods as main plot and four nutrient management practices as sub plot factors. The two establishment methods comprised of (i) conventionally tilled dry direct seeded rice (CT-

DDSR) followed by zero tillage (ZT) wheat (CT-DDSR fb ZT) (ii) puddled transplanted rice (Pu-TPR) followed by conventionally tilled (CT) wheat (Pu-TPR fb CT). The four nutrient management practices included: (i) 100% recommended dose (100% RDF; 150:45:45 and 80:60:40 kg N, P_2O_5, and K_2O ha^{-1} respectively for rice and wheat), (ii) Residue retention @ 5 t ha^{-1} of wheat on rice *fb* residue of rice on wheat + 75% RDF of each crop (RR +75%RDF), (iii) Nutrient expert (NE) dose (140:56:53; 140:60:45 kg N, P_2O_5, and K_2O ha^{-1} for rice and wheat respectively), (iv) Brown/green manuring of *Sesbania* in rice *fb* rice residue @ 3.5 t ha^{-1} in wheat +75% RDF of each crop (BM/GM *fb* R+75% RDF) and the treatments were replicated thrice. The variety of wheat 'Bijay' was sown @120 kg ha^{-1} with spacing 20 cm × continuous in the experimental units of size 14.4 m^2 (4.8m×3 m).

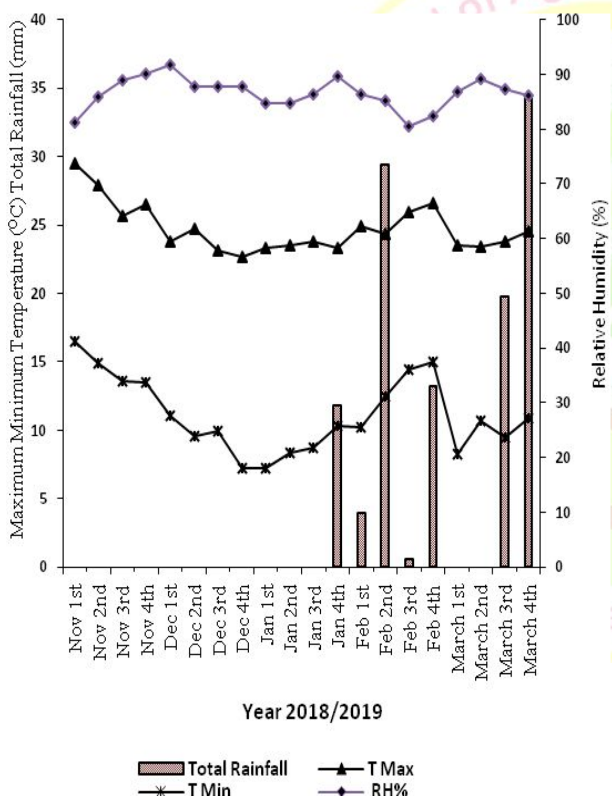

Figure 1. Minimum and maximum daily temperature (°C), daily rainfall (mm) and daily relative humidity during the experimental period at Rampur, Chitwan, Nepal, 2019 (Source: NMRP, 2019).

Crop management

During rice season, the field was tilled twice, planked and leveled and rice crop was established using two methods: dry seeds directly sown in rows (DDSR) and transplanted in puddled field (Pu-TPR). The wheat residue on rice crop @ 5 t ha^{-1} was applied as mulch in DDSR and incorporated in soil for Pu-TPR. For ZT wheat after DDSR, the plots were sprayed glyphosate-47L with 5ml L^{-1} was applied in the field a week prior to sowing and wheat was directly sown in lines. For CT, after Pu-TPR, the field was ploughed twice, pulverized and leveled and wheat was sown. For both establishment methods, seed was sown on 5th November 2018 in continuous manner in the rows spaced 20 cm apart.

The RDF used for rice and wheat was 150: 45:45; 80:60:40kg N, P_2O_5 and K_2O ha^{-1} respectively. The nutrient expert dose i.e.140:56:53; 140:60:45 kg N, P_2O_5, and K_2O ha^{-1} for rice and wheat respectively were calculated using Nutrient Expert Model of each crops developed by International Plant Nutrient Institute (IPNI). The residue amount varied with treatments and was used as surface mulch. Full dose of K_2O and P_2O_5 was applied through MOP and DAP as basal dose whereas N in each treatment was divided three equal splits and each split was applied at 0 DAS (basal dose), 30 days after sowing (DAS) and 60 DAS respectively. No irrigation and weed management practice was carried out.

Sampling and measurements

The effective tillers at harvest were counted from an entire row in the net plot area and expressed in per sq. meter. For the computation of sterility, 20 average spikes from each treatment were selected, the unfertilized and fertilized florets were counted and sterility was computed and expressed in percentage using the formula:

$$\text{Sterility (\%)} = \frac{\text{unfertilized florets}}{\text{total floret}} \times 100$$

The average grains per spike was also calculated form the same 20 selected average spikes. The crop was harvested at physiological maturity stage from the net plot area of 9.6 m^2 for determination of yield. The thousand grain weight (TGW) was also calculated from the grain lot by counting 1000 grains. The harvest index (HI) was determined by calculating the ratio of grain yield and biological yield and expressed in percentage. The B:C ratio was calculated by dividing the gross returns (based on the local market price of Chitwan) by total cost of cultivation

Statistical analysis

The recorded data were subjected to analysis of variance, and Duncan's multiple range test at α level 0.05 (DMRT) for mean separations (Gomez & Gomez, 1984). Dependent variables were subjected to analysis of variance using the R Studio for split plot design. Sigma Plot v. 12 was used for the graphical representation.

RESULTS AND DISCUSSION

The yield attributing characters, yield and economics of subsequent wheat as influenced by establishment methods and nutrient management practices of it and preceding rice crop is discussed below:

The average number of effective tillers per square meter at the time of harvest was 234.10. In response to establishment methods, Pu-TPR fb CT showed higher number of effective tillers per square meter than CT-DDSR fb ZT. Regarding the nutrient management practices, NE dose had shown significantly higher number of effective tillers (281.94 m^{-2}) (Table 2).

Significant interaction was seen between establishment methods and nutrient management practices for no. of effective tillers per sq. meter of wheat as shown in Figure 2.

Table 2. Number of effective tillers per square meter, number of grains per spike, thousand grain weight (g), sterility (%) of wheat as influenced by the establishment methods and nutrient management practices at Rampur, Chitwan, 2018-2019

Treatments	Number of effective tillers (m^{-2})	Number of grains per spike	Thousand grain weight (g)	Sterility (%)
Establishment methods				
CT-DDSR fb ZT	233.33	41.38	66.41	46.92
Pu-TPR fb CT	234.86	38.28	67.60	47.19
SEm (±)	6.76	0.78	0.24	0.27
LSD (=0.05)	ns	ns	ns	ns
CV, %	10.00	6.80	1.40	1.80
Nutrient management practices				
100% RDF	219.44[b]	38.55[b]	66.99	47.90
RR+75% RDF	214.72[b]	38.77[b]	66.70	47.32
NE dose	281.94[a]	44.48[a]	67.64	45.46
BM/GM fb R+75% RDF	220.28[b]	37.53[b]	66.69	47.54
SEm (±)	4.19	1.09	0.73	0.86
LSD (=0.05)	12.90	3.35	ns	ns
CV, %	4.40	6.70	3.20	3.80
Grand mean	234.10	39.81	67.01	47.07

Note: CT-DDSR, conventional tillage dry direct seeded rice; Pu-TPR, puddled transplanted rice; fb, followed by; CT, conventional tillage; ZT, zero tillage; Residue#, Residue retention (5 t ha^{-1}); Residue@, Residue retention (3.5 t ha^{-1}); RDF, recommended dose of fertilizer (80:60:40 kg N, P_2O_5, K_2O ha^{-1}); NE, nutrient expert (140:60:45 kg N, P_2O_5, K_2O ha^{-1}); DAS, days after sowing**.** Same letter(s) within column represent non-significant difference at 0.05 level of significance based on Duncan multiple range test.

The interaction showed that, under both establishment methods, the no. of effective tillers per sq. meter was statistically higher for NE dose treated plots and was even significantly higher for Pu-TPR fb CT than CT-DDSR fb ZT. The residue applied treatments were similar in terms of effective tillers per sq. meter but superior than 100% RDF under CT. In contrast to which, 100% RDF under ZT had higher effective tillers than residue applied treatments

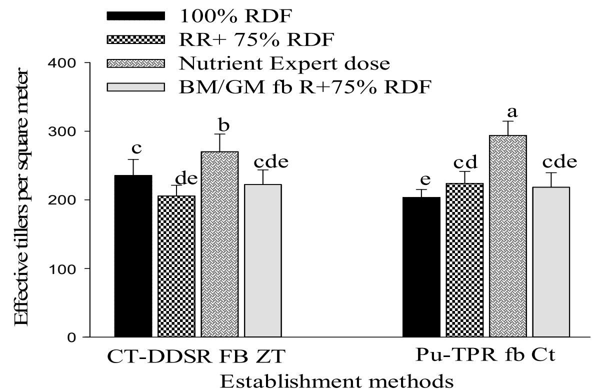

Figure 2. Number of effective tillers (m^{-2}) meter at the time harvest of wheat as influenced by the interaction of establishment methods and nutrient management at Rampur, Chitwan, 2018-19

Note: CT-DDSR, conventional tillage dry direct seeded rice; Pu-TPR, puddled transplanted rice; fb, followed by; CT, conventional tillage; ZT, zero tillage; RR, Residue retention (5 t ha^{-1}); BM, brown manuring; GM, green manuring , R, residue retention (@3.5 t ha^{-1}); RDF, recommended dose of fertilizer (80:60:40 kg N, P_2O_5, K_2O ha^{-1}); NE, nutrient expert (140:60:45 kg N, P_2O_5, K_2O ha^{-1}); DAS, days after sowing**.** Same letter(s) represent non-significant difference at 0.05 level of significance based on Duncan multiple range test.

The average number of grains per spike was 39.81 which was about 8% higher for CT-DDSR fb ZT than that for Pu-TPR fb CT and regarding the nutrient management practices, NE assisted nutrient management was significantly higher 44.48 grins per spike. The average thousand grain weight (TGW) was 67.01g and sterility was 47.07% respectively but none of them were found significantly different among the various nutrient management practices and crop establishment methods. However, CT-DDSR fb ZT had relatively lesser TGW and sterility. Among the nutrient management practices, Ne dose had relatively higher TGW and lesser sterility.

The higher number of tillers in 100% RDF under ZT might be due to the better soil moisture conservation (Moraru & Rusu, 2013); better nutrient mobility and higher N availability due to lesser loss due to rapid mineralization (Thomas et al., 2007) than the conventional tillage and favorable environment created due to absence of puddling in DSR. In addition to this, the tillage operation also hastened the decomposition and mineralization process thereby increasing the nutrient availability in residue applied treatments (Halvorson, Wienhold, & Black, 2002) and hence relatively higher tillers were observed in residue applied plots under CT compared to 100% RDF which lacked residue. Under ZT, conserved soil moisture

increased the nutrient availability and uptake by the plants, resulted in better nutrient use efficiency (Hulugalle & Lal, 1986; Halvorson et al., 2002). Hence, the grains per panicle increased under CT-DDSR fb ZT. Since, the grains per spike has inverse relationship with TGW and sterility, the increased grains per spike resulted in lower TGW and lower sterility than Pu-TPR fb Ct. In addition to this, increased pollen viability and hence higher grains per panicle and lower sterility was recorded under CT-DDSR fb ZT.

Grain and straw yield and harvest index (HI)

The average grain yield of wheat under ZT planted after DSR was 11.44% lower than under CT after TPR. But the difference was not significant and same case was pragmatic with straw yield and HI; the average straw yield and HI were 4.41 t ha^{-1} and 38.41% respectively. The grain yield was 15.5% more under NE dose assisted nutrient management practices and significantly higher straw was obtained under NE dose as shown in Table 3.

Table 3. Grain yield (t ha^{-1}), straw yield (t ha^{-1}) and harvest index (%) of wheat as influenced by the establishment methods and nutrient management practices at Rampur, Chitwan, 2018-2019

Treatment	Grain yield (t h^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
Establishment methods			
CT-DDSR fb ZT	2.97	4.73	36.19
Pu-TPR fb CT	3.31	4.25	40.62
SEm (±)	0.11	0.33	2.47
LSD (=0.05)	ns	ns	ns
CV, %	12.40	25.60	22.30
Nutrient management practices			
100% RDF	2.84	3.83^{b}	40.09
RR+75% RDF	3.02	4.38^{b}	37.18
NE dose	3.43	5.95^{a}	33.60
BM/GM fb R+ 75% RDF	3.28	3.80^{b}	42.76
SEm (±)	0.20	0.37	2.42
LSD (=0.05)	ns	1.14	ns
CV, %	15.20	20.20	15.50
Grand mean	3.14	4.41	38.41

Note: CT-DDSR, conventional tillage dry direct seeded rice; Pu-TPR, puddled transplanted rice; fb, followed by; CT, conventional tillage; ZT, zero tillage; RR, Residue retention (5 t ha^{-1}); BM, brown manuring; GM, green manuring , R, residue retention (@3.5 t ha^{-1}); RDF, recommended dose of fertilizer (80:60:40 kg N, P_2O_5, K_2O ha^{-1}); NE, nutrient expert (140:60:45 kg N, P_2O_5, K_2O ha^{-1}); DAS, days after sowing**.** Same letter(s) within column represent non-significant difference at 0.05 level of significance based on Duncan multiple range test.

The higher yield of wheat under conventional system might primarily be due proper seed bed and cropping which resulted in the the destruction of weed seeds, soil pathogens, lack of interference by residues and similar explanation was given by Bahrani, Kheradnam, Emam, Ghadiri, & Assad (2002). Sainju, Lenssen, Caesar-Tonthat, & Waddell (2006) and Busscher, Bauer, & Frederick (2006) harvested higher yields under conventional tillage as compared to no tillage or reduced tillage and explained that greater inorganic N and N uptake can be optimized and potentials for soil erosion and N leaching can be reduced by this treatment.

The better yield attributing parameters under nutrient expert model dose might be due to higher doses of fertilizer i.e. 75% more N and 12.25% more K_2O than for 100% RDF. The increased N dose had resulted in significant increase in number of grain per spike, number of spikes per square meter and hence had lowered sterility. Similar explanations were also given by Woyema (2012); Abedi, Alemzadeh, & Kazemeini, (2011); Maqsood, Ali, Aslam, Saeed, & Ahmad, (2002)and Ali et al. (2002). In the same manner, nutrient expert follows the principle of SSNM which provides the nutrient based on the crop demand and at the right time. Improved timing and/or splitting of fertilizers increased nutrient use efficiency under nutrient expert model assisted nutrition management (Khurana et al., 2005)and aided in yield improvement. BM/GM fb R+75% RDF yielded 15.49% more yield compared to 100% RDF (Table 3). The plots under this treatment had residual effects of *Sesbania* crop grown in the previous rice season and the finding was in accordance with (Hoque et al., 2017) who found yield advantage of 38% in wheat crop planted after the green manuring practices in rice field. The favorable soil environment due to the addition of OM and conservation of beneficial microbes due to the green and brown manuring practices in rice field might be responsible for the improved yield under BM/GM fb R+75% RDF (Hoque, Akter, & Islam, 2017).

Economic analysis

The average total cost of production, gross return, net return (NRs. ha^{-1}) and B:C ratio of wheat were NRs.60793.54, NRs.98721.12 and NRs.37927.58 ha^{-1} respectively as shown in Table 4. and were not significantly different among the establishment methods. The net return under NE dose was 49% more than 100% RDF and hence had significantly higher B:C ratio.

The significantly lower net returns and B:C ratio under RR+75% RDF was due to the added cost of rice residue as it is a valueable byproduct and main source of roughage feed for livestock. Despite having about NRs. 6000 ha^{-1} more gross return and reduction of cost of 25% fertilizers compared to 100% RDF, the net return from RR+75% RDF was about NRs. 7000 ha^{-1} lesser than 100% RDF due to cost incurred for residue. The higher cost of production under Pu-TPR fb CT was due to the added cost for the tillage operations. The significantly higher B:C ratio under NE was due to

significantly higher yield which fetched higher benefits over added cost of fertilizers. These findings were also in accordance with the results of by Kumar & Batra (2017), Khan et al. (2017), Kumar et al. (2015), Tripathi (2010), and Lales et al. (2008).

Table 4. Total cost of production gross returns, net returns (NRs. ha^{-1}) and B:C ratio of wheat as influenced by the cropping systems, establishment methods and nutrient management practices at Rampur, Chitwan, 2018-2019

Treatments	Total cost of production (NRs. ha^{-1})	Gross return (NRs. ha^{-1}),	Net return (NRs. ha^{-1})	BC ratio
Establishment methods				
CT-DDSR fb ZT	58143.54	93809.62	35666.08	1.63
Pu-TPR fb CT	63443.54	103632.62	40189.08	1.64
SEm (±)		4911.50	2261.497	0.004
LSD (=0.05)		ns	ns	ns
CV, %		10.70	27.90	9.10
Nutrient management practices				
100% RDF	54525.44	88933.44	34408.00	1.64^{ab}
RR+75% RDF	67951.58	94979.58	27028.00	1.39^{b}
NE dose	57620.56	108772.31	51151.75	1.89^{a}
BM/GM fb R+ 75% RDF	63076.58	102199.16	39122.58	1.62^{ab}
SEm (±)		2823.68	5062.07	0.10
LSD (=0.05)		ns	ns	0.30
CV, %		14.80	38.50	14.70
Grand mean	60793.54	98721.12	37927.58	1.63

Note: CT-DDSR, conventional tillage dry direct seeded rice; Pu-TPR, puddled transplanted rice; fb, followed by; CT, conventional tillage; ZT, zero tillage; RR, Residue retention (5 t ha^{-1}); BM, brown manuring; GM, green manuring , R, residue retention (@3.5 t ha^{-1}); RDF, recommended dose of fertilizer (80:60:40 kg N, P_2O_5, K_2O ha^{-1}); NE, nutrient expert (140:60:45 kg N, P_2O_5, K_2O ha^{-1}); DAS, days after sowing. Same letter(s) within column represent non-significant difference at 0.05 level of significance based on Duncan multiple range test.

CONCLUSION

The wheat crop was not much affected by the establishment methods of preceding rice crop and itself however, it was much more productive and profitable under Nutrient expert model dose. The residue application in the field was beneficial under the conventional tillage practice but the residue application also reduced the profitability of the crop whereas the practice of brown manuring and green manuring in rice also improved the yield of subsequent wheat crop with the improvement of soil health and saving of 25% RDF.

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Research Article

Effect of planting dates and sources of nitrogen on growth and yield of cauliflower at Rampur, Chitwan, Nepal

Binaya Baral[*], Manisha Shrestha, Binod Pokhrel and Puspa Raj Dulal
Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal
**Corresponding author e-mail: binayabaral55555@gmail.com*
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ABSTRACT

Appropriate time of planting and use of suitable sources of nitrogen are highly conducive for better growth and yield of cauliflower. A field experiment was conducted to study the effect of planting dates and sources of nitrogen on growth & yield of cauliflower at horticulture research block of Agriculture and Forestry University, Rampur, Chitwan, Nepal from 1st Nov 2019 to 4th March 2020 using 'Snow mystic', a late season variety of cauliflower. The study was laid out in split-plot design with two dates of planting (Dec 1st & Dec 16th) as main plot factors & four sources of nitrogen viz. 100% biochar (BCH), 100% Urea(U), 50% urea+ 50% Poultry manure (U+PM) & 50% Biochar+ 50% poultry manure (BCH+PM) against a control as sub-plot factors and were replicated thrice with 30 experimental units each of 9 m2 size containing 5 rows with 5 plants per row. The recommended dose of fertilizer used for the research was 108:92:60 kg N, P2O5, K2O ha-1 and P and K were supplied through SSP and MOP. The soil of experimental plot was sandy loam with slightly acidic with pH (5.6). The data regarding days to 90% curding, canopy area (cm2), leaf number per plant, above ground dry mater (g m-2) (AGDM), curd size (cm2) and curd weight per plant(g), days to curding to harvesting interval, yield, HI and B:C ratio were recorded and analysed using MS Excel and R studio. Significantly higher number of leaves per plant (16.03), bigger average canopy area (5089.93 cm2), higher AGDM (217.91 g m-2), bigger (1563.03 cm2) and heavier curds (1412.44 g) were recorded in 1st Dec. transplanted cauliflower with significantly higher harvest index (68.20). Regarding the sources of nitrogen, all the above parameters were seen better under BCH+ PM but were statistically at par with other nitrogen sources except control. The 1st Dec. planted crop had 4 more days of curding to harvesting interval than 16th Dec. planted one but the difference was not significant. December 1st planted cauliflower yielded 110% more yield and net returns than 16th Dec. planted crop whereas BCH incurred maximum cost (NRs 322145 ha-1) and U and U+PM were the most profitable in terms of B:C ratio (12.77 and 12.96 respectively).Hence, better crop yield and benefit could be obtained by planting the late season cauliflower (var. Snow mystic) at 1st Dec with the use of 100% urea or U+PM as nitrogen source in plains of Nepal having Chitwan like climate.
Keywords: Cauliflower, Bio-char, planting dates, Nitrogen source

INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. Botrytis, 2n=2x=18) is one of the most important commercial winter vegetables grown throughout the world, which belongs to the family Brassicaceae. In, Nepal it can be successfully grown from terai to high hills. Globally, 26.5 million tonnes of cauliflower was produced with a yield of 1,86,937 kg/ha in 2018, led by China & India (FAOSTAT, 2018). In Nepal, cauliflower is one of the highly preferred vegetables cultivated in about 34,967 ha, which shares 14.9 % (550044.8 Mt) of the total vegetable production of the country (Ghimire, Lamsal, Paudel, Khatri, & Bhusal, 2018). It is an annual crop that is propagated by seed & grown in both normal as well as in the offseason with appropriate technology. The white tender head (curd) is consumed as roasted, boiled, fried, steamed, or even raw alone or with other vegetables (Sahito et al., 2018), while the rest part like stalk and leaves are used in animal feeds. Cauliflower is low in fat but rich in carbohydrates, protein, vitamins, minerals, and antioxidants.

Cauliflower can be grown in a wide range of climatic conditions but being a very sensitive crop it needs distinct climatic conditions for its transformation from vegetative to curd initiation and its development (Ray

& Mishra, 2017). The cool moist climate is best for its cultivation and the head doesn't form well in hot weather conditions. Temperature plays an important role in the formation, development & quality of curd (Naik, Babu, & Lakshminarayana, 2016). The high temperature at curd development and maturity period result in low-quality curd (Naik et al., 2016). The optimum time for curd formation is 15.2 oC with an average maximum of 25 oC and a minimum of 8 oC (Naik et al., 2016). Hence proper planning of the planting dates is very important for the optimization of the crop.

Proper sowing and transplanting dates in cauliflower influence all the yield parameters (Naik et al., 2016). Transplanting times differ with the varieties cultivated in particular agro-climatic conditions prevailing in a particular region (Gill H S and Sharma S R, 1996). Cauliflower is grown in early, mid to late and late varieties. Late varieties of cauliflower are cultivated from November to March. Maturity in cauliflower varies with the seasons of years, fall plantings take the longest to mature which is followed by planting in winter and spring (Howe & Waters, 1982).

Cauliflower is a heavy feeder and its productivity depends on the use of balanced fertilizer and there may be considerable loss in the yield if not adequately fertilized (Chatterjee, 1993). N plays an important role in the growth & development of plants (Yoldas, Ceylan, Yagmur, & Mordogan, 2008). A yield of 50 t ha-1 cauliflower removes approximately 200 kg of N, 85 kg P, and 270 kg K (Bashyal, 2013). And their uptake by plant reduce their availability in soil over time after crop harvesting, as those plant used nutrients are not returned into the soil (Fajardo et al., 2016). In order to fulfill the requirement, there is excess use of inorganic fertilizer. But in the long run, it has a detrimental impact on soil health, ecology, and other natural resources which affect soil microorganisms and also human beings (TEKASANGLA & Department, 2015) hence a sustainable approach to nutrient management is a must.

Biochar is a highly stable charcoal-like solid carbon-rich, highly porous organic biomass that is obtained by pyrolysis (direct thermal decomposition of biomass in the absence of oxygen) (Narzari, Bordoloi, Chutia, & Borkotoki, 2015). Biochar application increases the absorption capacity, cation exchange capacity, and pH of the soil (Hagab, Eissa, Abou-Shady, & Abdelmottaleb, 2016) and also helps in retaining water and nutrients in the soil and used by the plants as they grow. Using biochar in soil enhances adoption towards climate change impacts & carbon sequestration purposes due to the recalcitrant nature of biochar (Dahal, Bajracharya, & Merz, 2018). Commercial fertilizer demand is reduced by 8-12% and saved 8-10% of the cost with the co-application of biochar with fertilizers (Li et al., 2017).

In Chitwan, farmers can be encouraged for cauliflower production during winter by increasing the yield which can be achieved through the selection of proper planting time and appropriate sources of nitrogen. Hence, the research is carried out to assess the effect of planting dates and sources of nitrogen on the overall performance and economics of cauliflower (variety snow mystic) at Rampur, Chitwan.

MATERIALS AND METHODS

Site description

The field experiment was conducted at the research block of horticultural farm of Agricultural and Forestry University, Rampur, Chitwan Nepal from 1st Nov 2019 to 4th March 2020. The experimental site is about 256 m above sea level and geo-graphically it is situated at latitude of 27^0 40' N and longitude of 84^0 23' E. The soil samples from the experimental site were collected & analysed in soil lab, where the soil is found to be slightly acidic with soil p^H of 5.6. The soil texture was found to be sandy loam with 4.2% organic matter content. The experimental site lies in the subtropical humid climate belt of Nepal. The weather conditions is sub-humid type with cool winter, hot summer, and distinct rainy season with rainfall of about 2000mm per annum. The weather data during the cropping season of cauliflower was recorded from NASA Power website. (Figure-1)

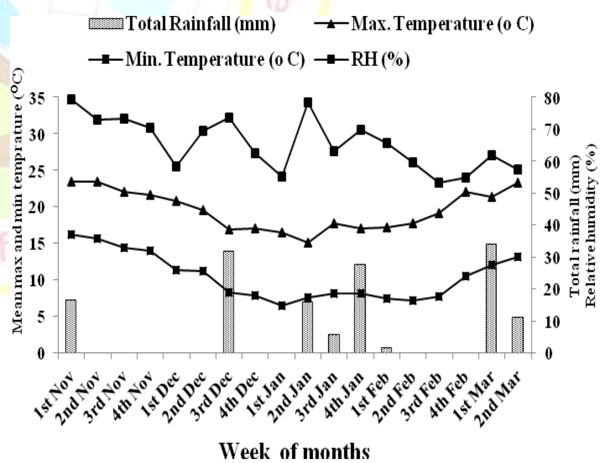

Figure 1. Mean maximum and minimum daily temperature (^oC), relative humidity and Total rainfall (mm) during Nov - 2019 to March 2020, at Rampur, Chitwan, Nepal.

The average maximum temperature of 19.57 ^0C was recorded which ranges from 15.13-23.5 ^0C while average minimum temperature was 10.41 ^{0} C which ranges from 6.45- 16.19 ^0C. The average relative humidity was 65.57% ranging from 53.18-79.49% with total rainfall of 144.53 mm ranging from 0-33.98 mm.

Experimental design and treatments

The experiment was carried out in Split Plot Design, with two factors i.e. two dates of planting, (1st Dec & 16th Dec) as main plot factor and four sources of nitrogen viz. 100% bio-char(BCH), 100% urea(U), 50% urea+ 50% Poultry manure(U+PM) & 50% BCH+ 50% PM(BCH+PM) against control as sub-plot factors and were replicated thrice with 30 experimental units each 9 m^2 size containing 5 rows with 5 plants per row.

Crop management

Seed of Snow Mystic variety of cauliflower were shown on two different dates (Nov 1st & Nov 16th) in the raised nursery beds of 3*1 m in size. And a month old healthy, uniform size & height of cauliflower seedlings were transplanted with the spacing of 60cm* 60cm.

The recommended dose of fertilizer used for the research was 108:92:60 kg N, P_2O_5 , K_2O ha^{-1} and P and K were supplied through SSP and MOP. The nitrogen applied from the various sources was applied based on their nitrogen content determined from the laboratory analysis. The laboratory analysis of PM showed 3% N content and cow Urine soaked BCH contain 4% N. Different intercultural operations like weeding, gap filling, earthing up, irrigations, & plant protection measures like using insecticides & fungicides were done according the requirements during the crop growing period. And they were harvested after the curds attained the marketable size.

Sampling and Measurements

The biometrical observations like number of leaves per plant, plant canopy covered (cm^2), days to curd initiation, days to curd harvest, days to curding to harvest interval, weight of marketable curd per plant(g), curd area (cm^2), total (AGDM) above ground dry matter (g/m^2), economical yield(t ha^{-1}), harvest index (HI), and B:C ratio were recorded from randomly selected 5 plants in each plot and average were calculated. Regarding days to curding days, days to 90% curding days were recorded and harvested at horticultural maturity. The fresh weight of leaves, stem and curd were oven dried and expressed in above ground dry matter (g m^{-2}). The HI was determined by calculating the ratio of dry weight of curd and total dry weight and is expressed in percentage. And the B:C ratio was calculated by dividing the gross return by total cost of cultivation of cauliflower based on the local market price of Chitwan during the experimental period.

Statistical analysis

The observed data were recorded in MS Excel and were subjected to analysis of variance, and Duncan's multiple range test at a level 0.05 (DMRT) for mean separations based on (Gomez & Gomez, 1984). Dependent variables were subjected to analysis of variance using the R Studio for split plot design. Sigma Plot v. 12 was used for the graphical representation.

RESULTS AND DISCUSSION

The growth of cauliflower in terms of leaf production, canopy covered, the major yield attributes, yield and economics of cauliflower as influenced by the date of planting and source of nitrogen is presented and discussed below:

The number of leaves per plant and the canopy area covered by cauliflower were significantly influenced by dates of planting and sources of nitrogen. The average leaf number per plant 8-14.6 and the average canopy covered by each plant increased from 1436.72cm^2 to 4849.44cm^2 respectively from 30 days after transplanting (DAT) to 75 DAT. The average leaf number per plant was found significantly different only at 60 and 75 DAT. At 60 DAT, the leaf numbers of cauliflower transplanted on Dec 1st (12.56) were statistically higher than that on Dec 16th (11.56). And similar trend was also followed for 75 DAT. Similar findings also reported by (Ara, Kaisar, Khalequzzaman, Kohinoor, & Ahamed, 2009) with 19.53 leaves with early planting. More number of leaves in early planting may be due to the warmer temperature which results in more vegetative growth (Islam, Datta, & Chatterjee, 2016); (Kumar, P.T., Babu, S.D., Aipe, K.C., 2002).Whereas all the sources of nitrogen were statistically similar in terms of leaf production and were statistically higher over control for both 60 and 75 DAT. Increased leaf number and plant spread might be due to nitrogen which contribute an increase in leaf buds (SANGEETA SHREE*, 2014).

The average canopy area per plant was significantly influenced by the date of planting and sources of nitrogen. December 1st planted cauliflower plant covered significantly higher canopy area at all dates of observations except than December 16th except for 75 DAT where the difference in canopy area was not found significant. Regarding the sources of nitrogen, at 30 DAT and 60 DAT, U+PM, BCH, BCH+PM had significantly higher and similar canopy coverage. The average canopy coverage of cauliflower per plant at 75 DAT was statistically similar in U+PM, BCH+ PM, Urea whereas BCH had significantly lower canopy coverage than these sources of Nitrogen. Oyedeji et al., 2014 also recorded that plant growth using inorganic (NPK) and PM increases soil fertility where inorganic perform better.

Yield attributes and yield

Days to curding & harvesting

The average number of days at which 90% of the plant started curd development was neither significantly affected by the planting dates nor the sources of nitrogen and average days at which 90% of plants

showed curd development was 68.83. The crop was ready for harvesting at average of 80.48 days and this was significantly different between the plants planted at different dates. Dec 16th planted cauliflower were ready for harvest for about six days earlier than Dec 1st planted crop but the days to harvesting was not significantly influenced by the sources of nitrogen. The longer crop duration in early planting might be due to higher temperature in early growth stage resulting in more vegetative growth period than in later planting and was in accordance of the explanations of (Islam et al., 2016).According to Ara, N., Kaisar, M.O., Khalequzzaman, K.M., Kohinoor, H., Ahamed, (2009), quick curd initiation on late planting was due to the exposure of plant to favourable climate for shorter period for vegetative growth and the subsequent higher temperature hastened the curd initiation and hence reached the harvesting stage faster than early planted cauliflower.

Curd area, fresh curd weight at harvest and above ground dry matter (AGDM)

The average curd area, average fresh weight of curd, average AGDM production, and yield were significantly influenced by the dates of planting and sources of nitrogen. The average total AGDM production, average curd area, average curd fresh weight was significantly 99.5%, 93.41% and 111% more in Dec 1st planted cauliflower than Dec 16th planted ones. All these parameters were significantly higher over control but statistically at par with each other under all sources of nitrogen. According to Almaz, Halim, & Martini, 2017 chemical fertilizer could be substituted by 50 % using PM without reducing crop yield. Malick (1994) also reported highest curd area with early plantation and Uddin, M.R., Dey, S., Islam, M.R., (2011) stated that bigger sized curd in early planting was due to low temperature during vegetative growth. Higher dry matter production under early planting might be due to more photosynthate accumulation due to longer crop period. Hassan, (2019) also reported that curd diameter as well as weight gradually decrease with delay in planting. This differences might be due to the variation in the growth environment and climatic parameters during the growth period as stated by period (Islam et al., 2016). Also, the yield in production of cauliflower increased by 14.6 t/ha by using biochar (Khadka, 2017). Kumar, Das, Prasad, & Kumar, 2013 recorded that co-application of organic and inorganic fertilizers significantly increased the yield in broccoli over inorganic fertilizers alone.

Table 1: Average number of leaves and average canopy area (cm^2) per plant as influenced by the planting dates and sources of nitrogen at Rampur, Chitwan during 2019-2020

Treatments	30 DAT		45 DAT		60 DAT		75 DAT	
	canopy	Leaf No.	canopy	Leaf No.	canopy	Leaf No.	canopy	Leaf No
Date of transplanting								
Dec 1st	1895.37a	7.64	3631.10a	9.81	4710.87a	12.56a	5089.93	16.03a
Dec 16th	978.08b	8.36	2043.81b	9.95	3680.41b	11.56b	4608.95	13.69b
SEM (±)	458.65	0.36	793.65	0.067	515.23	0.5	240.49	1.17
LSD (=0.05)	152.38	NS	104.01	NS	489.05	0.263	NS	1.18
CV, %	6.8	7.5	2.3	21.5	7.4	1.4	7.7	5.1
Nitrogen sources								
Control	1163.07c	7.77	2215.87c	9.80	2748.08c	11.17b	2936.53c	13.50b
BCH	1552.09a	8.40	2994.03a	9.83	4480.67ab	12.37a	5000.03b	15.03a
Urea	1349.30b	7.87	2867.22b	10.30	4287.38b	12.33a	5124.33ab	15.20a
U+ PM	1601.15a	7.93	3203.64a	9.57	5098.93a	12.30a	5772.95a	15.37a
BCH+ PM	1517.99a	8.03	2906.54b	9.90	4363.15ab	12.13a	5413.33ab	15.20a
SEM (±)	80.46	0.109	165.93	0.12	389.17	0.23	496.40	0.34
LSD (=0.05)	101.65	NS	158.64	NS	737.07	0.82	693.43	0.93
CV, %	5.8	6.2	4.6	5.9	14.4	5.5	11.7	5.1
Grand mean	1436.72	8	2837.46	9.88	4195.64	12.06	4849.44	14.86

Note: BCH, 100% Biochar; Urea, 100% Urea; BCH+ PM, 50% Biochar +50% Poultry Manure; U+PM, 50% Urea + 50% Poultry Manure

Yield and Harvest Index (HI)

The average yield of cauliflower and the HI was also found significantly influenced by the date of planting and sources of nitrogen. Yield and HI were significantly (111%, 17.31% respectively) more under December 1st planting. All the sources of nitrogen were similar in terms of yield and HI and were superior over control. This difference might be due to lowering down of average maximum and minimum temperature in delay planting & in early planting, crop remain in field for long period accumulating more photosynthates which result in higher yield and HI (Gautam, B.P.,

Shadeque, A., Saikia, 1998) and (Hassan, 2019). And in presence of organic fertilizer, inorganic N was found more effective in curd yield of cauliflower (Gamel, 2008). Khadka (2017) found 14.6 t ha^{-1} yield increment of cauliflower through the biochar application.

Table 2: Phenology, yield attributes and yield of cauliflower as influenced by the planting dates and sources of nitrogen at Rampur, Chitwan, 2019-2020

Treatment	Days to Curding	Days to harvesting	Curd Area (cm²)	Curd Fresh Weight (g)	Total AGDM (g m-2)	Yield (t ha-1)	Harvest Index
Date of transplanting							
Dec 1st	69.40	83.20a	1563.03a	1412.44a	83.20a	39.24a	68.20a
Dec 16th	67.87	77.76b	808.12b	669.68b	77.76b	18.60b	50.89b
SEM	0.77	2.72	377.46	371.38	2.72	10.32	8.65
LSD (=0.05)	NS	1.49	378.20	339.50	1.49	9.45	8.06
CV, %	9.7	1.2	20.3	20.8	1.2	20.8	8.6
Nitrogen sources							
Control	69.33	80.20	564.27b	434.63b	80.20	12.07b	57.34b
BCH	66.67	80.17	1253.33a	1129.97a	80.17	31.39a	62.19a
U	70.50	80.90	1332.87a	1181.13a	80.90	32.81a	58.60ab
U+ PM	68.33	80.47	1346.35a	1205.17a	80.47	33.48a	59.002ab
BCH+ PM	68.33	80.67	1431.07a	1254.4a	80.67	34.86a	60.60ab
SEm (±)	0.63	0.14	157.87	152.93	0.14	4.25	0.84
LSD (=0.05)	NS	NS	328.15	322.06	NS	8.96	3.89
CV, %	4	0.8	22.6	25.3	0.8	25.3	5.3
Grand mean	68.63	80.48	1185.58	1041.06	80.48	28.92	59.54

Note: BCH, 100% Biochar; Urea, 100% Urea; BCH+ PM, 50% Biochar +50% Poultry Manure; U+PM, 50% Urea + 50% Poultry Manure

Table 3: Total cost production, Gross and net return ($NRs.ha^{-1}$) and B:C ratio of cauliflower as influenced by the dates of planting and sources of nitrogen at Rampur, Chitwan during 2019-2020

Treatment	Cost (NRs.ha-1)	Gross Return (NRs.ha-1)	Net return (NRs.ha-1)	B:C ratio
Dates of planting				
Dec 1st	150349.8	1177294.2a	1026944.4a	10.41a
Dec 16th	150349.8	558111.4b	407761.6b	5.11b
SEM (±)		309591.4	309591.4	2.65
LSD (=0.05)		283413.7	283413.7	1.05
CV, %		20.8	25.2	8.7
Sources of Nitrogen				
Control	72145e	362223.4b	290078.4c	5.02b
BCH	322145a	941714.2a	619569.2b	2.92c
Urea	77059d	984356.5a	907297.5a	12.77a
U+ PM	77700c	1004386a	926686a	12.93a
BCH+ PM	202700b	1045833.7a	843133.7ab	5.16b
SEM (±)	49507.4	127477.1	119967.8	2.12
LSD (=0.05)	2.3	268726.7	268726.7	1.91
CV, %	0	25.3	30.6	20.1
Grand mean	150349.8	867702.8	717353	7.76

Economic Analysis

The total cost of production, gross and net returns and B:C ratio of cauliflower as influenced by the dates of planting and sources of nitrogen is as shown in Table 3. The average cost of cultivation was NRs. 150349.8 and highest cost was incurred in BCH treatment followed by BCH+PM, U+PM. The gross return did not vary among the sources of nitrogen but were significantly higher than control and December 1st planted cauliflower gave higher gross return. The December 1st planted cauliflower gave NRs. 619182.8ha^{-1} more net returns and had twice B:C ratio than the later planted one. The net return under Urea, U+ PM, BCH+ PM were statistically similar but the returns under BCH was lower because of the higher cost incurred for the biochar preparation and urine treatment. Hence, it also had smaller B:C ratio compared to other nitrogen sources.

Linear and significant relationship was seen between AGDM and yield and curd area and yield with high correlation coefficient and coefficient of determination as shown in figure 2.

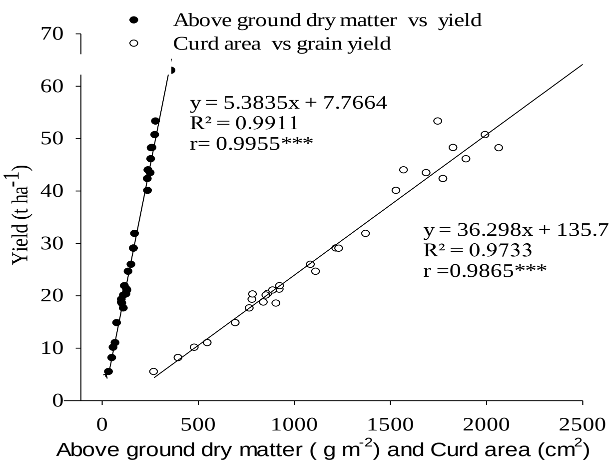

Figure 2: Relationship between above ground dry matter production and curd area with grain yield

CONCLUSION

December 1st was the most appropriate date of planting of late season variety of cauliflower and the supplement of nitrogen from any of the considered sources was equally effective. The profit could be doubled by planting the seedlings at 1st December.

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Research Article

Study of production performance of Uttara breed of chicken

Sushil Kumar Singh, Anil Kumar, D.V. Singh and R.K. Sharma
Department of Livestock Production Management, College of Veterinary and Animal Sciences, G. B. Pant University of Agri. & Tech., Pantnagar-263 145, Uttarakhand, India
**Corresponding author e-mail: drsushilsingh@gmail.com*
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ABSTRACT
Present study was conducted on Uttara chicken to evaluate the productive performance. Day Old Chicks (DOC) of which were obtained from hatchery Instructional Poultry Farm of G.B. P.U.A.T., Pantnagar. Weekly body weight was recorded from day old to 12 weeks of age and at the end of trial (i.e. after 12 weeks of age) three birds were randomly selected and slaughter for study of carcass traits parameters. It has been found that Uttara fowl under farm condition performed better in context of productive parameters viz. weight gain, dressing percentage, edible weight percentage, processing loss etc. These findings clearly revealed that Uttara chicken has genetic potential for further improvement and also suitable for backyard poultry farming in hilly areas of Uttarakhand.
Keywords: Uttara, weight gain, backyard poultry

INTRODUCTION
Among livestock, poultry plays an important role in providing nutritional security as well as the source of income to rural families in Uttarakhand. Demography of the state is a limiting factor in the propagation of intensive poultry farming, backyard poultry can play a vital role with low input income generation activity. Backyard poultry farming is a traditional & old age practice in the underprivileged section of the rural community of Uttarakhand. In this context rearing of indigenous chicken, varieties become important. The introduction of improved germplasm of indigenous chicken can bring a significant improvement in sustainable backyard poultry production in hilly areas of Uttarakhand.

Keeping these points in view, the present study was designed to evaluate the growth and carcass traits of "Uttara" a native chicken of Uttarkhand. This chicken breed has been evolved through natural selection and is well adapted to the local environment. These birds possess an appreciable degree of resistance to diseases compared with other exotic chicken breeds. Since this breed has a feathered shank, Uttara chickens are also resistant to cold winter stress and can thrive very well under adverse environments like poor housing, poor management, and poor feeding. These birds are black in color and have crest/crown type structure on the head due to which they have socio-economic importance.

In the present study, a trial was conducted to study the production performance traits of farm conditions.

MATERIALS AND METHODS
Day-old chicks for the present study were produced at a university farm from the existing breeding stock of Uttara parental lines. These DOCs were obtained simultaneously from one hatch so that their subsequent rearing could be done under similar environmental and managemental conditions. All standard brooding management was practiced with proper feeding and watering. The experiment was conducted for a period of 12 weeks.

Statistical analysis

The experimental data obtained during the study were finally analyzed statistically using a completely randomized design (CRD) with the analysis of variance (ANOVA) technique which is based on the test statistics F (or variance ratio) which is given by Snedecor (Snedecor and Cochran, 1994). For fulfilling this purpose data were analyzed by the one-way ANOVA option for the general linear model of SPSS 16.0 software is used.

RESULTS AND DISCUSSION
Average body weights at end of the 2nd and 4th weeks were 96.23±4.32 g and 195.83±14.76 g, respectively, which were higher than the reports of Kaur (2007) in

Uttara fowl. The value reported in the present study was found higher than the study conducted by Gurung and Singh (1999) and Binda et al. (2012) and higher 4th-week bodyweight than the present study were reported by Saadey et al. (2008), Enaiat et al. (2008), Rach-Moujahed (2011) and Taha et al. (2011) in different indigenous local breeds other than the Uttara chicken.

Table 01: Average body weight (Mean±S.E.) of Uttara Chicken

Age (in weeks)	Weight (in gm)
Hatch weight	36.11±1.15
2nd week body weight	96.23±4.32
4th week body weight	195.83±14.76
6th week body weight	310.17±17.38
8th week body weight	480.00±24.62
10th week body weight	641.63±25.74
12th week body weight	837.00±24.23

Table 02: Other important parameters of Uttara chicken during trial

Parameters	Age	Value (Mean±S.E.)
Egg weight(g)	-	52.67±1.56
Percent livality	0-12 weeks	82.61
Dressing percent		72.42±0.41

The average 6th and 8th weeks body weights of Uttara chicken were found as 310.17±17.38 and 480±24.62 g, respectively, which were higher than the reports of Kaur (2007). Gurung and Singh (1999) and Binda et al. (2012) also found lower body weight at eight weeks of age in different indigenous local breeds than the values reported in the present study while Saadey et al. (2008), Enaiat et al. (2008), Rach-Moujahed (2011) and Taha et al. (2011) reported higher body weight at eight weeks of age in different indigenous local breeds than the values reported in the present study.

Average 10th and 12th-week body weights in the present study were reported as 641.63±25.74 and 837±24.23 g, respectively, which were again found higher than Kaur (2007) in Uttara chicken than the present study. Gurung and Singh (1999) and Pradhan et al. (2009) reported lower twelve-week body weight in different indigenous local breeds than the corresponding values reported in the present study while Saadey et al. (2008), Enaiat et al. (2008), Rach-Moujahed (2011) and Taha et al. (2011) reported higher body weight at twelve weeks of age in different indigenous local breeds than the values reported in the present study.

The dressing percentage was 72.52±0.41 which was found lower than the findings of Kaur (2007) and Pant (2007), while it was in agreement with Magala et al. (2012) in Ugandan local chickens, Thutwa et al. (2012) in the normal strain of Twasana and lower dressing percentage was obtained by Sahota et al. (1990), Jaturistha et al. (2008) and Iqbal et al. (2009) different indigenous local chickens.

CONCLUSION

The results of this study help to shed more light into the growth characteristics of Uttara fowl and suggests that Uttara fowl is a promising native breed of Uttarakhand and has genetic potential for improvement through intensive selection and breeding programme to develop birds with improved efficiency for sustainable use in poultry farming in harsh and cold of hilly region of Uttarakhand for the benefits of rural farmers who main rear the birds. If birds are adequately fed, one can easily plan for instance, when to market them to raise cash for specific household needs such as paying for school fees. Research should focus on improvement of growth parameters such as reducing the half-growth time and increasing asymptotic weights without increasing cost of production. Findings from such studies and the ones presented here could be a significant prelude to the improvement of the Uttara fowl.

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Research Article

Performance of Chickpea (*Cicer arietinum* L.) Genotypes in Sunsari district of Province no. 1 Nepal

Govinda Prasad Timsina[1], Sujan Karki[1], Binod Kumar Gupta[1], Rajendra Darai[2], Sabita Sharma[3] and Shree Prasad Vista[4]
[1]*Jute Research Programm, Itahari, Sunsari, NARC, Nepal*
[2]*National Grain Legumes Research Program, Khajura, Banke, NARC, Nepal*
[3]*Directorate of Agricultural Research, Tarahara, Sunsari, NARC, Nepal*
[4]*National Soil Science Research Centre, NARC, Khumaltar*
**Corresponding author e-mail: timsinagp_2005@yahoo.com*
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ABSTRACT
The present study was carried out to know the performance of growth, yield contributing characters, and reaction against insect pests and disease on chickpea genotypes at Jute Research Program, Itahari, Sunsari, Nepal. A total of twelve chickpea genotypes were sown in Randomized Complete Block Design (RCBD) with three replications and each replicate had 10 lines with an inter and intra row spacing of 40 cm and 10 cm respectively. It is of great interest to consider the per se performance of different genotypes on various characters of economic importance, particularly earliness, plant height, nodule number, pod number, seed diameter, 100 seed weight, seed yields, pest and disease incidence. The genotypes ICCV-87312 showed earlier in flowering and maturity while the genotypes KWR-108 and Tara showed the highest and lowest plant height respectively. Likewise, the yield and yield components of overall pooled mean performance of chickpea genotypes ICCV-840508-38 born the maximum pod number, seed diameter, hundred seed weight, and seed yields. With respect to pest incidence, genotype KWR-108 was found to be less susceptible while genotype Tara was found to be more susceptible against pest damage (pod damage). Similarly, the genotypes ICCV-87312 found to be less susceptible while genotypes ICCV-98937 were found to be more susceptible against fusarium wilt disease among the tested genotypes. On the basis of the mean performance of yield components and biotic stress components observed in the present study, the five genotypes viz., ICCV-840508-38, ICCV-98933, KPG-59, ICCV-87312, and KWR-108 were found to be superior genotypes. Therefore, farmers and chickpea producers around study areas and similar agro-ecologies can use those genotypes for chickpea production as well as these materials can be used for the further breeding programs too.
Keywords: Chickpea, Genotypes, Yields, Insect pest, Disease etc.

INTRODUCTION
Legume crops are an essential part of the daily diet for people in many developing countries where a larger proportion of the population cannot afford animal products. Chickpea (*Cicer arietinum* L.) is an important legume crop widely distributed and cultivated throughout the globe. Chickpea commonly known as Chana in Nepal is an important and unique food riched in carbohydrates, dietary fiber, and protein, and the protein quality is considered to be better than other pulses (Jukanti et al., 2012). It is an important legume to the population, as it is the primary protein source for nearly 2 million Nepalese people (Pande et al., 2005). Besides being an important source of human and animal food, chickpea also plays an important role in the maintenance of soil fertility, particularly in dry, rain-fed areas (Saxena, 1990 and Katerji et al. 2001). Globally, the chickpea is cultivated on about 11.08 million ha adding 9.77 million tons of grains to the global food baskets with average productivity of 882 kg ha-1. The chickpea is the third most important grain legume in the world after dry beans and dry peas. Its cultivation is mainly confined to Asia with 90% of the global area and production (Ali and Kumar 2001). In Nepal, it is the second most important pulse crop after lentil and predominantly grown under rain-fed conditions which

occupy 9653 ha of areas with the production of 10675 Mt (AICC, 2020). Chickpea faces diverse environments for its production in terms of photoperiod, temperature, and precipitation, all of which have a profound effect on growth and development (Khanna-Chopra and Sinha 1987). Chickpea is grown in tropical, subtropical, and temperate regions. It is a valued crop and provides nutritious food for an expanding world population and will become increasingly important in the context of climate change. Chickpea is an important winter legume grown mainly in the rainfed area of Nepal, mainly in rice or maize-based ecosystem either as a sole or mixed crop with other winter crops.

The average productivity of chickpea in Nepal is much lower than the world's average and is also lower as compared to other chickpea-growing countries of Asian regions. There are many factors responsible for low yield, but among those factors use of traditional or low yielding varieties and poor adoption of management practices are considered most important. Nonetheless, chickpea production is being constrained due to several biotic and abiotic stresses worldwide. Among the biotic stresses, fusarium wilt, ascochyta blight, pod borer, cutworm, and abiotic stresses such as drought, heat, soil salinity, low soil fertility, and poor crop management practices are the most important limiting factors in crop production. Improvement in yield and quality of the crop is the primary objective and selection of superior plants is the basis of crop improvement. The efficiency of selection depends on the identification of genetic variability from the phenotypic expression of the characters. Estimation and use of genetic diversity of the available genetic resources are key factors for a successful breeding program (Renganayaki et al., 2001) aimed at improving crop performance under biotic and abiotic stresses. Therefore, this study was incited with the objective to test the performance of chickpea genotypes for their adaptability on growth, yield and yield-related traits, pest, and disease incidence in the study areas.

MATERIALS AND METHODS

The experiment was conducted at the experimental field of Jute Research Programm, Itahari, Sunsari (at 26o15' north latitude and 87o 20' east longitude) during two successive growing periods in 2018 and 2019. A total of twelve chickpea genotypes were sown in Randomized Block Design (RBD) with three replications and each replicate had 10 lines with an inter and Intra row spacing of 40 cm and 10 cm respectively. Individual plot size was 4m x 2.4 m =9.6 m2 and 1 m and 1.5 m between plot and block respectively. Seeds of chickpea genotypes were collected from the National Grain Legumes Program, Khajura, Banke. The seed was sown in rows on the trail plot and placed at 2-3 cm depth in each row. Two seeds were sown in each hill. The recommended dose of fertilizer was applied at the time of planting. All other agronomic management was applied uniformly in all experiment plots as per the national recommendation for the crop. Observation and data collection was carried out from the experiment fields. Data were collected during the experiment time both from the whole plot, net plot, and sampled plants by random selection from the middle of four rows of each plot. Observations on the following quantitative and qualitative characters were recorded on ten randomly selected plants from each plot in each replication. These plants were tagged before flowering. The data were recorded on Days to emergence, Days to 50% flowering, Days to maturity, Early plant stand, Final plant stand, Plant height (cm), Branch number, Nodule number, pod number per plant, seed number per pod, seed diameter (mm), 100 seed weight (gm), seed yields (ton/ha), pest and disease incidence (%). The incidence of pests (pod borer) was recorded at the time of maturity. All the pods of 10 randomly selected plants were plucked and number of healthy and damaged pods were counted and percent pod damage was calculated by using the following formula,

$$\text{Pod damage (\%)} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

Similarly, field observations of naturally occurring fusarium wilt incidence were done at 7- day interval at sick plot based on percent of wilt incidence in each plot. Initial recording data for fusarium wilt disease incidence was done when wilting symptoms were visible on the three to five basal leaves of the plants. Disease incidence (DI) on each experimental unit was calculated by using the following formula:

$$\text{DI (\%)} = \frac{\text{Number of plants that show wilt symptoms}}{\text{Number of both disease infected plants and healthy plants}} \times 100.$$

Analysis of variance (ANOVA) was computed for grain yield and other traits as per the methods described by Gomez and Gomez using Genstat 15th edition computer software for Randomized Complete Block Design.

RESULTS AND DISCUSSION

Crop phenology

Statistical analysis of crop phenology data showed the significant ($P \leq 0.05$) difference in both the year's aspects days to emergence among the tested twelve chickpea genotypes. The flowering duration of testing genotypes ranges from 82 to 92 and 85 to 96 days while the maturity days range from 126 to 135 and 143 to 153 days respectively during two successive growing seasons. The mean performances for these traits are presented in Table-1. The chickpea genotypes showed early flowering and maturity at first, growing season as

compared to the second growing season. This might be due to differences in the day length and temperature of the two growing seasons. The pooled mean over a year for flowering and maturity days ranges from 84 to 93 and 138 to 143 days respectively. The earliest 50% flowering was observed from genotypes ICCV-87312 (84 days), while later flowering was observed from genotypes ICCV-97207 (93 days). Similarly, the early maturing genotypes were observed from genotypes ICCV-87312 and KPG-59 (138 days), while later maturing was observed from the genotypes ICCV-98937 and Tara (143 days) among the tested genotypes (Table 1). Similar results for the mean and range for days to 50% flowering and days to maturity in chickpea genotypes were reported by (Jakhar et. al. 2016) that days to 50% flowering ranges from 51.67 to 82.67 days and days to maturity ranges from 105 to 123 days. The variation in these characters may be due to the genetic makeup of the genotypes.

Table 1: Mean value of crop phenology related traits of 12 genotypes of chickpea tested at JRP, Itahari, Sunsari in 2018 and 2019 cropping season.

	Days to emergence			Days to 50% flowering			Days to maturity		
Genotypes	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
ICCV-87312	9	9	9	82	85	84	132	143	138
ICCV-98937	9	9	9	90	89	89	133	153	143
ICCV-97207	9	10	9	90	95	93	130	153	142
ICCV-840508-38	9	10	10	87	92	90	129	150	139
ICCV-840508-40	9	9	9	86	92	89	128	150	139
ICCV-840508-41	9	9	9	92	86	89	129	150	140
KWR-108	9	9	9	90	93	92	129	151	140
ICCV-98933	9	9	9	88	87	88	126	151	139
KPG-59	9	9	9	87	91	89	129	146	138
BG-372	9	9	9	86	92	89	132	151	142
ICCV X 840508-31	9	9	9	86	94	90	131	146	139
Tara	9	9	9	89	96	92	135	151	143
Grand Mean	9	9	9	88	91	89	130	150	140
F - Value	NS	NS	NS	**	**	**	**	**	**
LSD (0.05)	-	-	-	3.05	4.8	3.23	1.49	4.03	2.2
C.V (%)	7.2	6.5	5.9	2.1	3.1	2.1	0.7	1.6	0.9

*, Significant at $P \leq 0.05$. **, $P \leq 0.01$. LSD, least significant difference. CV, coefficient of variance,

Growth Traits

Evaluated genotypes showed significant ($P \leq 0.05$) differences in plant height and nodule number while it showed non-significant differences on early plant stand, final plant stand, and branch number (Table 2). Mean performances of genotypes for plant height during the 2018 growing season ranges from 38 to 50 whereas, the mean performance of genotypes tested during the 2019 growing season ranges from 36 to 49 respectively. The mean values of chickpea for plant height ranged from 38 to 47 with pooled mean values of 43. The highest plant height was observed from genotypes KWR-108 (47cm) while the lowest plant height was observed from genotypes Tara (38 cm). Similar results for mean and range for plant height in Chickpea varieties were also reported previously by (Dan et al., 2016, Ejara et. al., 2020 and Ercan et. al., 2013). (Sikdar et.al., 2015) also reported that variation among the varieties in respect of plant height appears due to genotypic variation.

Similarly, the nodule per plant was observed significantly ($P \leq 0.05$) differently among the tested genotypes during the two successive growing seasons. Genotypes showed considerable variations in nodule number that ranged from 6 to 13 with the pooled mean performance 9. Six genotypes recorded a superior number of nodules than the mean performance of genotypes (Table 2).

Yield and Yield Components

The variation of genotypes in pods number per plant, seed diameter, hundred seed weight, and seed yield per hectare showed significantly ($P \leq 0.05$) different on tests genotypes while it showed a non-significant difference in seed number per pod (Table 3). The mean performance of pod numbers ranges from 10 to 31, 15 to 70, and 16 to 42 during two consecutive growing seasons and pooled mean respectively. Similarly, the variation in seed diameter ranges from 6.4 to 8.6 and 5.4 to 7.6 (mm) during the 2018 and 2019 growing seasons respectively. The pooled mean performance of seed diameter ranges from 5.9 to 8.1. With respect to a hundred seed weight the range ranges from 17.9 to 27.6, 14.7-29.4, and 16.4 to 28.5 (gm) during 2018, 2019, and overall mean respectively. Likewise, the seed yield of the chickpea genotypes ranges from 0.6 to 2.8, 1.5 to 6.9, and 1.2 to 4.4 (ton/ha) respectively during two growing seasons and overall pooled mean. Further,

the overall pooled mean performance of genotypes showed the highest number of pods (42), seed diameter (8.1mm), hundred seed weight (28.5 gm), and seed yields (4.4 ton/ha) from genotypes ICCV-840508-38 (42) while the lowest number of pods (16) from genotypes BG-372, seed diameter (5.9mm), hundred seed weight (16.4 gm) from genotypes ICCV-87312, and lowest seed yields (1.2 ton/ha) from genotypes ICCV-840508-41 respectively. The considerable variations in pod number, seed number per plant, and seed per pod were also reported by other authors in Chickpea (Dan, et al. 2016, Ejara et. al. 2020, Ercan, et al. 2013, and Getachew, et al. 2015). (Sikdar et.al., 2015) reported the variation in the number of pods plant –1 was found due to the variation of branch production and also the genetic variations. (Kabir and Sarkar, 2008) reported that the variation in 100 seed weight of the varieties of chickpea might be due to their different genetic characteristics. (Walia et.al., 2019) reported that yields of different chickpea lines/varieties ranged from 157.5 to 425.4 kg ha−1.

Table 2: Mean value of growth related traits of 12 genotypes of chickpea tested at JRP, Itahari, Sunsari in 2018 and 2019 cropping season.

	Early Plant Stand (no.)			Final Plant Stand (no.)			Plant Height (cm)			Branch/plant (no.)			Nodules/plant (no.)		
Genotypes	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
ICCV-87312	157	185	171	157	124	140	40	39	39	3	3	3	7	6	6
ICCV-98937	138	249	194	135	117	126	46	38	42	3	2	3	6	7	6
ICCV-97207	129	147	138	126	99	113	41	49	45	2	3	3	13	13	13
ICCV-840508-38	144	147	145	142	79	111	43	46	44	3	3	3	10	11	11
ICCV-840508-40	152	190	171	149	109	129	45	42	43	3	3	3	7	7	7
ICCV-840508-41	130	137	134	126	64	95	39	41	40	3	3	3	10	9	10
KWR-108	142	163	153	142	103	123	50	44	47	3	3	3	9	9	9
ICCV-98933	131	156	143	131	88	109	45	48	46	3	3	3	8	7	8
KPG-59	146	141	143	146	53	100	41	49	45	3	2	3	13	12	12
BG-372	123	165	144	123	79	101	47	36	42	2	3	3	7	6	6
ICC X 840508-31	133	151	142	132	74	103	44	42	43	3	3	3	10	11	10
Tara	125	167	146	125	92	108	38	38	38	3	3	3	10	10	10
Grand Mean	138	167	152	136	90	113	43	43	43	3	3	3	9	9	9
F-value	NS	NS	NS	NS	NS	*	**	**	**	NS	NS	NS	**	**	**
LSD(0.05)	-	-	-	-	-	26.42	3.86	7.12	4.27	-	-	-	2.95	3.03	2.93
C.V(%)	15.4	24	14.2	15.6	30.6	13.8	5.3	9.9	5.9	14.9	15.6	14.6	19	20.1	19.1

*, Significant at P ≤ 0.05. **, P≤0.01. LSD, least significant difference. CV, coefficient of variance,

Table 3: Mean value of yield and yield components traits of 12 genotypes of chickpea tested at JRP, Itahari, Sunsari in 2018 and 2019 cropping season.

	No. of pod/plant			No. of Seed/pod			Seed diameter (mm)			100 seed Wt. (gm)			Seed Yields (ton/ha)		
Genotypes	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
ICCV-87312	31	47	39	1	1	1	6.4	5.4	5.9	18.2	14.7	16.4	2.1	2.8	2.5
ICCV-98937	18	46	32	1	2	1	7.2	6.1	6.7	17.9	21.7	19.8	1.2	3.2	2.2
ICCV-97207	10	31	20	2	1	1	8.4	7.3	7.9	19.7	21	20.3	1.1	4.7	2.9
ICCV-840508-38	15	70	42	1	1	1	8.6	7.6	8.1	27.6	29.4	28.5	2.8	5.9	4.4
ICCV-840508-40	11	43	27	1	1	1	8.0	6.9	7.4	19.7	22.7	21.2	2.1	2.8	2.5
ICCV-840508-41	17	18	18	1	1	1	6.5	5.5	6.0	20.7	25.3	23.0	0.8	1.5	1.2
KWR-108	22	41	31	2	1	1	7.1	6.1	6.6	19.7	22.0	20.9	1.7	3.0	2.3
ICCV-98933	16	49	32	1	1	1	7.8	6.8	7.3	17.3	23.0	20.1	1.4	6.9	4.2
KPG-59	17	65	41	1	2	1	7.1	6.1	6.6	18.9	25.0	21.9	1.8	6.3	4.0
BG-372	17	15	16	1	1	1	7.1	6.1	6.6	20.6	24.3	22.5	1.0	1.9	1.4
ICC X 840508-31	21	21	21	2	1	1	7.7	6.7	7.2	20.7	21.7	21.2	1.2	2.2	1.7
Tara	15	61	38	2	1	1	7.1	6.1	6.6	19.7	22.3	21.0	0.6	2.8	1.7
Grand Mean	17.4	42.3	29.8	1.4	1.3	1.3	7.4	6.4	6.9	20.0	22.8	21.4	1.5	3.7	2.6
F-value	**	**	**	NS	NS	NS	*	*	*	**	**	**	**	**	**
LSD (0.05)	2.5	16.1	8.5	-	-	-	1.3	1.3	1.3	3.6	3.4	2.2	1.2	1.0	0.9
C.V(%)	8.3	22.5	16.7	16.8	21.9	14.5	10.2	11.9	11.0	10.5	8.9	6.1	20.4	16.0	21.3

*, Significant at P ≤ 0.05. **, P≤0.01. LSD, least significant difference. CV, coefficient of variance,

Biotic stress component

Insect pests and diseases are the major biotic stress factors of chickpea production. Analysis of variance on biotic stress components showed significant ($P \leq 0.05$) differences on test genotypes. Insect pest mainly chickpea pod borer [*Helicoverpa armigera* Hubner) Lepidoptera, Noctuidae] is the main devastating pest of the crops. Pod damage (%) by pod borer was significantly different among the test genotypes (Table 4). The overall mean performance of the two consecutive growing seasons showed that the maximum amount of pest incidence (pod damage) was recorded from genotypes Tara (50.3%) followed by genotypes ICCV-840508-40 (49.4%) and BG-372 (48.2%) respectively and considered as more susceptible genotypes against chickpea pod borer. Similarly, the pest incidence was minimum in genotypes KWR-108 (15.3%) followed by genotypes ICCV-98933 (26.1%) and ICCV-87312 (26.3%) respectively, and considered comparatively less susceptible genotypes against chickpea pod borer. The results of pod damage percentage are in agreement with the results of the authors who stated similar findings, i.e., varieties with more pod borer infestation had more percentage damaged pods and vice versa (Sarwar et al., 2011). (Nadeem et al., 2011) studied ten advanced chickpea genotypes against pod borer and reported that pod damage ranged from 8.2 to 15.8%. (Hossain, 2009) recorded pod damage range from 2.80 to 13.47/plant in 20 different chickpea genotypes and found that the genotype with maximum pod damage was most susceptible. (Parkash et al. 2007) reported 60.1- 94 and 70-95% pod damage by chickpea pod borer respectively. The much variation in pod damage may be due to differences in regional climatic conditions and the tested genotypes.

Fusarium wilt is a major disease of chickpea which causes economic damages to the crops. The overall pooled mean performance of the disease incidence on chickpea ranges from 14.3 to 26.9 % with the mean value of 20.5% respectively (Table 4). The maximum amount of disease incidence was recorded from genotypes ICCV-98937 (26.9%), followed by genotypes KPG-59 (24.8%) and BG-372 (24%) respectively, and considered as more susceptible genotypes against the wilt and blight diseases. Likewise, the minimum amount of disease incidence was recorded from genotypes ICCV-87312 (14.3%), followed by genotypes ICCV-97207 (15.3%) and KWR-108 (15.7%) respectively, and considered as less susceptible genotypes against wilt and blight diseases. Diseases, such as *Fusarium* wilt and *Ascochyta* blight have affected the crop throughout the growing season and at the pod set, respectively. (Anjaneya Reddy, 2002) suggested that complete wilting, plants exhibited turgidity losses and yellowing of leaves in a plant infected with wilt disease. (Ahmad et al., 2010) indicated that some of the cultivar showed resistance reaction at the seedling stage while others showed susceptible reaction at the physiological maturity stage. (Iqbal et al., 2010) were identified five genotypes with genes for tolerance against wilt disease which could be further utilized for developing high yield cultivars with dual tolerance.

Table 4: Mean value of biotic stress component traits of 12 genotypes of chickpea tested at JRP, Itahari, Sunsari in 2018 and 2019 cropping season.

	Pest Incidence (%)			Disease Incidence (%)		
Genotypes	2018	2019	Mean	2018	2019	Mean
ICCV-87312	41.2	11.3	26.3	11.6	16.6	14.3
ICCV-98937	74.6	13.6	44.1	26.4	27.7	26.9
ICCV-97207	64.7	4.3	34.5	12.6	18.8	15.3
ICCV-840508-38	54.1	4.8	29.5	15.8	24.8	19.1
ICCV-840508-40	64.6	34.2	49.4	17.3	23.1	19.9
ICCV-840508-41	36.6	20.2	28.4	18.5	28.8	23.6
KWR-108	23.1	7.4	15.3	13.7	18.5	15.7
ICCV-98933	33.6	18.6	26.1	15.8	22.1	19.0
KPG-59	66.7	15.1	40.9	18.1	32.7	24.8
BG-372	70.1	26.4	48.2	21.1	26.3	24.0
ICC X 840508-31	40.6	35.6	38.1	17.8	26.6	22.3
Tara	70.3	30.4	50.3	18.1	22.7	20.6
Mean	53.35	18.49	35.9	17.2	24.0	20.5
F-value	**	**	**	*	*	**
LSD(0.05)	16.08	12.33	9.58	5.54	7.90	4.05
C.V (%)	16.6	49.4	15.7	19.0	19.6	11.7

*, Significant at $P \leq 0.05$. **, $P \leq 0.01$. LSD, least significant difference. CV, coefficient of variance,

CONCLUSION

The results of this investigation showed significant variation among the genotypes in growth, yields, pest, and disease incidence traits among the genotypes studied. On the basis of the mean performance of yield components and biotic stress components observed in the present study the five genotypes viz., ICCV-840508-38, ICCV-98933, KPG-59, ICCV-87312, and KWR-108 were found to be superior genotypes. Therefore, farmers and chickpea producers around study areas and similar agro-ecologies can use those genotypes for chickpea production as well as these genotypes can be used for further breeding programs too.

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Research Article

New records of Common Wolf Snake *Lycodon aulicus* (Linnaeus, 1758) (Serpentes: Colubridae) from Uttar Pradesh (India), with distribution of other Indian species

Akhlaq Husain
Former Sr. Scientist, ZSI,41, Hari Vihar, Vijay Park, Chakrata Road, Dehra Dun 248001, Uttarakhand
**Corresponding author e-mail: drakhlaqhusain@gmail.com*
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ABSTRACT
Present study deals with the new records of *Lycodon aulicus* (Linnaeus, 1758), the Common Wolf Snake, belonging to family Colubridae, from Shikohabad (Firozabad district) and Ghaziabad proper(Ghaziabad dist.), Uttar Pradesh (India) with its systematic account, distribution, habitat, food & feeding, breeding, behaviour, threats and distribution of other Indian species.
Keywords: New records, *Lycodon aulicus*, Uttar Pradesh.

INTRODUCTION
The snakes of Uttar Pradesh are meagerly known (Wall, 1907a. b; Smith, 1943; Talukdar & Dasgupta, 1977; Basu, 1989; Sankaran, 1989; Hellermann et al., 2001; Das *et al*., 2012; Mohan, 2020). Kanaujia *et al*. (2017) listed 38 species from Uttar Pradesh but didn't mention the district or locality and even the zones in which they divided the state. They considered *Gongylophis conicus* and *Eryx conicus* separate species which is not justified as being *G. conicus* is a synonym of *E. conicus* (ref. reptile-database). Further, they mentioned *Argyrogena fasciolata* twice in their list at Sl. Nos. 13 and 20.

Recently two good specimens of *Lycodon aulicus* (Linnaeus, 1758), the Common Wolf Snake, were sighted at Shikohabad (Firozabad district) and Ghaziabad (Ghaziabd district) located in south-west and western parts respectively of Uttar Pradesh state, which have not been recorded earlier from these districts and hence reported here. These will be the first records of any snake or reptile from the area.

COLLECTION SITE 1: RUKANPUR, SHIKOHABAD

Physiography: Shikohabad (27.6° 29' N Latitude and 78.35° 12' E) is a town in Firozabad district in south-west of Uttar Pradesh, with 252 m elevation, River Sirsa flowing through it. Rukanpur is a residential area in the city, on Etawah road.

Climate: Maximum temperature av. 44° C in summer (May) and minimum av. 12° C in winter (January) with av. max. rainfall 350 mm (July) and humidity *ca*.80% (August).

Flora (residential area): *Monoon longifolium* (syn. *Poliyalthia longifolia*), the False *Ashoka* (Annonaceae); *Sabal palmetto*, the Sabal Palm (Arecaceae); *Delonix regia*, the Flame Tree (Lehuminosae); *Azadirachta indica*, the *Neem* (Meliaceae); *Bougainvillea glabra*, the Paper flower (Nytaginaceae); some flowering plants.

COLLECTION SITE 2: INDIRAPURAM, GHAZIABAD

Physiography: Ghaziabad (28.67° N and 77.42° E) is located in north-western Uttar Pradesh and part of National Capital Region of Delhi, with 204 m elevation. River Hindon flows through it. Indirapurm is a residential colony in Ghaziabad city.

Climate: Maximum temperature ranges av. 40° C in summer (May) and minimum av.8° C in winter (January) with av. max. rainfall 218 mm (July) and humidity 78% (August).

Flora: Typical of U.P. plains.

Mangifera indica, the Mango (Anacardiaceae); *Polyalthia longifolia*, the *Ashok* (Annonaceae); *Plumeria obtuse*, the *Champa* (Apocynaceae); *Ehretia laevis*, the Chamrod (Boraginacea); *Terminalia arjuna*, the *Arjun* (Combretacea); *Acacia auriculiformis*, the Ear-pod Wattle, *Bauhinia variegata*, the *Kachnar* and *Cassia fistula*, the *Amaltas* (Leguminosae); *Azadirachta indica*, the *Neem* (Meliaceae); *Ficus bengalensis*, the

Bargad, *F. religiosa* the *Peepal*, *F. virens*, the *Anjeer* and *Morus alba*, the *Shehtoot* (Moraceae); *Neolamarckia cadamba*, *Psidium guajava*, the *Amrood* and *Syzygium cumini*, the Jamun (Myrtaceae); *Nyctanthes arbor-tristis* the *Harsingar* (Oleaceae); *Neolamarckia cadamba*, the Kadamb (Rubiaceae); *Mimusops elengi*, the *Maulsari* (Sapotaceae), etc.

LYCODON AULICUS (LINNAEUS, 1758)

Systematic account and Distribution

Synonymy:

Coluber aulicus Linnaeus, 1754. *Mus. Adolph. Frider*., 1: 29, pl. 12, fig. 2 (type-locality: not known); Linnaeus, 1758. *Syst. Nat*., (10th Ed.), 1: 220/381.

Lycodon unicolor Boie, 1827. *Isis*: 551 (based on Russell, 1801. *Ind. Serp*., 2, pl. 39) (vide Smith, 1943).

Lycodon subfuscus Cantor, 1839. *Proc. Zool. Soc. London*, 1839: 50 (type-locality: Bengal).

Lycodon atropurpureus Cantor, 1839. I. c. s.: 50 (type-locality: Mergui, Tennaserim); Boulenger, 1890. *Faun. Brit. India*: 356; Boulenger, 1891. *Ann. Mag. Nat. Hist*., (6) 7: 463; Boulenger, 1893. *Cat. Snakes Brit. Mus*. (*Nat. Hist*.), 1: 356.

Lycodon aulicus, Guenther, 1864. *Reptiles of British India*: 316; Stoliczka, 1870. *J. Asiat. Soc. Bengal*, 39: 201; Boulenger, 1893. *Cat. Snakes Brit. Mus.* (*Nat. Hist*.), 1: 352; Wall, 1921. *Ophidia Taprobanica or Snakes of Ceylon*: 151; Waltner, 1974. *Cheetal*, 16; Husain & Ray, 1995. Reptilia. In: Fauna of Western Himalaya, Part 1, Uttar Pradesh. *Himalayan Ecosystem Series*: 163; Husain & Tilak, 1995. Snakes (Reptilia : Serpentes). In: Fauna of Rajaji National Park. *Fauna of Conservation Areas*, 5: 95; Lanza, 1999. *Tropical Zoology*, 12: 89-104; Daniel, 2002. *The Book of Indian Reptiles and Amphibians*; Das, 2002. *A Photographic Guide to Snakes and Other Reptiles of* India; Whitaker & Captain, 2008. *Snakes of India- the field guide*; Goonawaedene *et al.*, 2006. *The Herpetofauna of the Kanuckles Range. Amphibian and Reptile Research Organization of Sri Lanka*; Murthy, 2010. The *Reptile Fauna of India*; Khan, 2014. *Bull. Chicago Herp. Soc*., 49 (3): 33-34; Wallach *et al*. 2014 (in part). *Snakes of the World*: 391; Pawar & Qureshi, 2016. *Sauria*, 38 (1): 50-57; Tank & Sharma, 2016. *Herpetological Review*, 47 (3): 480; Kumari, 2017. *International Journal of Engineering, Science and Mathematics*, 6 (3): 284-287; Ganesh & Vogel, 2018. *Bon zoological Bulletin*, 67 (1): 25-29, 34-35, figs. 1a-h, 5, 6.

Lycodon aulicus oligozonatus Wall, 1909. *J. Bombay nat. Hist. Soc*., 19 (1): 89 (type-locality: Cannanore, S. India).

Ophites aulicus, Wall, 1921. *Ophidia Taprobanica or Snakes of Ceylon*; Teo & Rajathurai, 1997. *Garden's Bull. Singapore*, 49: 353-425.

Lycodon aulicus aulicus, Smith, 1943. *Faun. Brit. India*, 3 (Serpentes): 265, fig. 89.

Lycodon travancoricus (nec Beddome, 1871), Rao *et al*., 2005. *Zoos' Print Journal*, 20 (1): 1737-1740.

Lycodon cf. *aulicus*, Ganesh *et al*., 2020. *Amphibian & Reptile Conservation*, 14 (3) [Taxonomy Section]: 80, figs. c-e.

Vernacular Names: *Maroli* (Assamese), *Ghor-chitti Sanp* (Bengali), *Garar*, *Kavdya*, *Kawriwala* Sanp, *Sakhar* or *Sankhra Sanp* (Hindi).

Material Examined: 1 example (*ca*. 65 cm; appear fed on some rat), Syedain Mosque, Chowk Haji Aijaz Husain, Rukanpur, Shikohabad, District Firozabad, Uttar Pradesh, 19.i.2020 (night), by Er. Syed Babar Husain.

1 example (*ca*. 70 cm), ATS Advantage, near Ghazipur Border, Indira Puram, Ghaziabad (NCR Delhi), Uttar Pradesh, 6.ii.2020, by Dr. Vinod Khanna.

Diagnostic Features:

Morphology: Body slender/cylindrical with heavy-thick set; head stoutly-built, large, broader than neck; snout broad, much depressed, long, spatulate and projecting beyond lower jaw; upper lip swollen; nostrils small, directed upwards; eyes small; hemipenis fairly thin, cylindrical, short, slightly forked at tip, with smaller flounces and spines and extending up to 10th subcaudal scale.

Colouration: Head with a distinct creamy-white colour-mark across parietal scales, converging towards snout tip; upper lip white or spotted with brown; neck with a pale collar which may be absent; body brownish or greyish-brown above with 9-20 creamy-white narrow cross bars, forked on sides.

Scales/shields:

Head Shields: Rostral scale scarcely visible from above; nasals small, sutured, touching 1st and 2nd supralabials; loreal single, longer than broad, not touching orbit; internasals large, higher than broad, touching loreal; prefrontals vertically oblong and equal to frontal, broadly touching loreal and preocular; preocular single, touching (rarely not) frontal and 3rd labial; frontal triangular, slightly larger than supraocular, usually touching preocular; supraocular not touching prefrontal; postoculars 2, small; temporals usually 2+3+3; supralabials usually 9, 3rd – 5th touching orbit/eye; parietals very large, subequal in length; infralabials horizontally elongate, 10-11, 1st -5th touching genials. (Ganesh *et al.* (2020) found loreal-internasal not touching and nasal-prefrontal touching in *Lycodon* cf. *aulicus*).

Body Scales: Dorsals 17 : 17 : 15 rows, smooth and glossy, imbricate, with mild apical pits; preventrals usually 1-3; ventrals angulate laterally; anal divided, rarely entire; subcaudals paired.

Variations in dorsals, ventrals and subcaudals counts have been by various workers as under:

Guenther (1864) found 183-209 ventrals, anal entire in few and 57-77 subcaudals. Smith (1943) and Whitaker & Captain (2008) mentioned 172-214 ventrals and 57-80 subcaudals. Kumari (2017) observed 170-224 ventrals and 56-80 subcaudals. Ganesh & Vogel (2018) counted 1-3 preventrals; 180-206 ventrals and 61-78 subcaudals in males and 186-215 and 56-74 in females. Ganesh *et al*. (2020) reported 16 : 17 : 16 dorsal rows, 195+3 and 194 ventrals and 66 and 58 subcaudals (in *Lycodon* cf. *aulicus*).

Length: Total length 71 cm, tail 11 cm (Boulenger, 1893); 7.375" hatchlings (Wall, 1907b); male 76 cm, tail 14.5 and female 70 cm, tail 12 cm (Smith, 1943); 83 cm, males longer than females (Husain & Tilak, 1995); hatchlings 14-19 cm (Das, 2002); Adults 30-80 cm, hatchlings 14 cm (Whitaker & Captain, 2008); total length 71 cm, tail 11 cm and hatchlings 14-19 cm (Kumari, 2017); av.50.0 cm, largest female 71.9 cm; relative tail length avg. 0.172-0.204 in males,0.146-0.191 in females (Ganesh & Voge l, 2018); snout-vent length 449 mm, tail length 96 mm and 310 mm, 62 mm as *Lycodon* cf. *aulicus* (Ganesah *et al*., 2020); females larger than males (wikipedia); ca. 65 and 70 cm (present specemens).

Altitudinal Records: Plains to 1,800 m (Waltner, 1974; Husain & Ray, 1995); Plains and hills up to 2,000 m (Husain & Tilak, 1995); 213 m / 700 ft at Punakanaat, Travancore (Ganesh & Vogel, 2018); 204 m at Ghaziabad and 252 m at Shikohabad (present).

Distribution: South Asia and South-east Asia.

Uttar Pradesh: Ghaziabad and Shikohabad (present new records).

Rest of India: Almost throughout, including Andaman & Nicobar Islands. Andhra Pradesh (Kinelly/Kimdey Hills; Visakhapatnam dist.), Assam (Dibrugarh), Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jammu & Kashmir, Jharkhand (Junganathpur- Ranchi), Karnataka (Bengaluru; Mysore), Kerala (Kannur / Cannaannore, Malabar; Punaka-naat- Travancore; Waynad), Lakshyadeep, Madhya Pradesh (Balaghat; Bisrampur; Jabalpur), Maharashtra (Ahmednagar; Matheran), Odisha, Punjab, Rajasthan (Ajmer), Tamil Nadu (Alakan- Tiruchendur; Namakkal dist.), Tripura, Uttarakhand (Almora, Dehra Dun and Nainital; Rajaji Tiger Reserve) and West Bengal (Barnijunoh; Howrah; Kolkata; Paschim Bardhaman; Paschim Medinipur/West Midnapore).

Elsewhere: Bangladesh, Bhutan, China, Hong Kong, Indonesia, Malaysia, Mascarene Islands, Mauritius, Myanmar, Reunion Islands, Nepal, Pakistan, Philippines, Seychelles, Sri Lanka and Thailand.

Habitat: Lives under stone or old brick piles, hollow of trees, old houses and in deserted wells. It can climb small trees and bushes.

Food & Feeding: Feeds on geckos, skinks, mice, rats and shrews and also on frogs, toads and bird eggs. Skinks form almost its sole food (Guenther, 1864). Its 'fang-like' long teeth on both jaws help in holding and piercing the prey (Tank & Sharma, 2016).

Breeding: Oviparous; female lays 3- 16 elongated eggs in 2-3 bunches of about 3-5 eggs during summer season (Wall, 1907b; Husain & Tilak, 1995; Whitaker & Captain, 2008; Khan, 2014; Kumari, 2017; wikipedia; reptile database).

Behaviour: It is nocturnal and mostly inactive during the day time. Though non-venomous but of fierce habits and defends itself vigorously and can cause severe lacerations with its fine sharp fangs. It may feign death to lure the potential prey and to avoid being chased by predators (Pawar & Qureshi, 2016; Kumari, 2017).

Conservation Status: Not assessed.

Threats: Killings, being confused with Common Krait-like colour pattern.

DITRIBUTIONWISE 12 INDIAN SPECIES OF *LYCODON* FITZINGER, 1826

1. *Lycodon aulicus* (Linnaeus, 1758), the Common Indian Wolf Snake: India (as above), Bangladesh, Bhutan, China, Myanmar, Nepal and Pakistan and Sri Lanka.
2. *Lycodon striatus* (Shaw, 1802), the Barred Wolf Snake: India (Andhra Pradesh, Gujarat, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Telangana, Tamil Nadu and Uttar Pradesh), Nepal, Pakistan and Sri Lanka.
3. *Lycodon jara* (Shaw, 1802), the Twin-spotted Wolf Snake: India (Arunachal Pradesh, Assam, Bihar, Odisha, Uttarakhand and West Bengal), Bangladesh, Bhutan, Myanmar and Nepal.
4. *Lycodon capucinus* Boie, 1827, the Oriental Wolf Snake: India (Andaman & Nicobar Islands), Cambodia, China, Christmas Islands, Hong Kong, Indonesia, Laos, Malaysia, Maldives, Mauritius, Myanmar, New Guinea, Philippines, Reunion Island, Singapore, Thailand and Viet Nam.
5. *Lycodon anamallensis* Guenther, 1864, the Colombo Wolf Snake: India (Andhra Pradesh, Kerala, Puducherry and Tamil Nadu) and Sri Lanka.
6. *Lycodon hypsirhinoides* (Theobald, 1868): India (Andaman & Nicobar Islands).
7. *Lycodon laoensis* Guenther, 1864, the Laotian Wolf Snake: India (Arunachal Pradesh) Cambodia, China Laos Malaysia, Nepal Thailand and Viet Nam.
8. *Lycodon travancoricus* (Beddome, 1870), the Travancore Wolf Snake: India (Andhra Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha and Tamil Nadu).

9. *Lycodon flavomaculatus* Wall, 1907, the Yellow-spotted Wolf Snake: India (Gujarat, Madhya Pradesh, Maharashtra, Northern Western Ghats and Tamil Nadu).
10. *Lycodon tiwarii* Biswas & Sanyal, 1965, the Andaman Wolf Snake: India (Andaman & Nicobar Islands).
11. *Lycodon zawi* Slowinski et al., 2001, the Zaw's Wolf Snake: India (Assam, Meghalaya, Mizoram and Tripura), Bangladesh and Myanmar.
12. *Lycodon flavicollis* Mukherjee & Bhupathy, 2007, the Yellow-collard Wolf Snake: India (Andhra Pradesh, Karnataka,Tamil Nadu and Telangana).
13. *Lycodon deccanensis* Ganesh *et al*., 2020: India (Andhra Pradesh, Karnataka and Tamil Nadu).

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Figure1: *Lycodon aulicus*, the Common Wolf Snake from Shikohabad (Credit: Er. Syed Babar Husain)


Figure 2: *Lycodon aulicus*, the Common Wolf Snake from Ghaziabad (Credit: Dr. Vinod Khanna)

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Research Article

Yield and yield attributes of black gram (*Vigna mungo* L. Hepper) as influenced by phosphorus and boron in acid Inceptisol

Muddana Sri Sai Charan Satya* and Sanjay-Swami
School of Natural Resource Management, College of Post Graduate Studies in Agricultural Sciences, Central Agricultural University, Umiam (Barapani) - 793103, Meghalaya, India
**Corresponding author e-mail: csmuddana@gmail.com*
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ABSTRACT

A field experiment was conducted to investigate the effect of phosphorus and boron on yield and yield attributes of black gram. Four levels of phosphorus (0, 25, 50, 75 kg ha^{-1}) and four levels of boron (0, 0.5, 1.0, 1.5 kg ha^{-1}) were laid in split plot design with three replications. . The native soil had a pH 4.99, E.C. 0.42 dS m^{-1}, organic carbon 1.32%, available nitrogen 251.35 kg ha^{-1}, available phosphorus 13.68 kg ha^{-1}, available potassium 233.24 kg ha^{-1} and hot water soluble boron 0.054 ppm. The results revealed that application of phosphorus and boron have a synergistic effect on yield, content and uptake in seed and straw of black gram. Significant highest seed yield was found when 50 kg P_2O_5 ha^{-1} along with 1.5 kg B ha^{-1}. Significant plant height at 30 DAS (20.04 cm) and 60 DAS (39.31 cm) was found with the application of $P_{50}B_{1.5}$ whereas at maturity, the plant height was recorded maximum (43.01 cm) at $P_{50}B_{0.5}$. Whereas, highest number of pods per plant was recorded with combination of 75 kg P_2O_5 ha^{-1} and 1 kg B ha^{-1} (19.89) and lowest was recorded in control (11.93) where no phosphorus and boron has been applied. The highest seed index was obtained with combination of as 50 kg P_2O_5 ha^{-1} and 0.5 kg B ha^{-1} as 4.64 whereas, lowest as 2.54 in control respectively.
Keywords: Phosphorus, boron, acid soil, yield and yield attributes.

INTRODUCTION

Pulses are a significant commodity category of crops that provide the country's primarily extensive vegetarian population with high-quality proteins complementing cereal protein. Pulses account for 6-7% of the total food grain production in the nation. Its cultivation provides the means for fixing atmospheric nitrogen in their root nodules @ 72 to 350 kg ha^{-1} $year^{-1}$ (Tiwari and Shivhare, 2016). Pulses have many attributes, such as protein richness, improves soil quality and physical structure suitable for crop rotations and dry farming, and green pods for vegetables and nutritious cattle fodder. Pulse productivity depends mainly on appropriate nutrient management practices (Kumpawat, 2010). The entire area under pulses in India during 2013-14 was 25.23 M ha with the production of 19.27 million tonnes and an average productivity of about 764 kg ha^{-1} (Tiwari and Shivhare, 2016). Black gram (*Vigna mungo* L. Hepper) is an important pulse crop cultivated in India. It holds about 25-26 percent protein, 60 percent carbohydrates, 1.3 percent fat, and is loaded in phosphoric acid among all the pulses (Tamang and Sanjay-Swami, 2017). Being a legume crop, black gram not only builds soil fertility but also often plays a significant role for the successor crop in the nitrogen economy. It is essential to supply phosphorus, as it has beneficial effects on nodulation, nitrogen fixation, root production, growth and yield. Phosphorus (P) is the second important macronutrient necessary for growth and development of plants (Brady and Weil, 2008). It involves in the development of seedlings, growth of early roots, early head formation and speed up crop maturity (Alinajoati and Mirshekari, 2011). Black gram also responds well to the fertilization of boron (B) in B deficient soils as boron is an important micronutrient that have crucial role in multiple physiological and biochemical functions in plants such as cell wall formation, cell division and enlargement, sugar translocation, metabolism of nitrogen, metabolism of carbohydrates and water relations (Oyinlola, 2007; Marschner, 2012). It is also essential in cell division and cell elongation (Camacho-

Cristobal *et al.*, 2015). More pronounced increase in the activity of polyphenol oxidase and peroxidase in the combined deficiency of boron and phosphorus may be due to the potential accumulation of o-diphenol like substances in deficiency of B (Hewitt, 1983). The combined deficiency of boron and phosphorus further increases the activity of enzymes, acid phosphatase, peroxidase, and polyphenol oxidase, which results in phosphorus deficiency. The growth and metabolism of plants was more inhibitory than the combined abundance of boron and phosphorus alone. This will show another synergistic effect of excess P and a combination of excess boron and phosphorus. Decline in (starch, sugar content, DNA, RNA and ribonuclease activity) have been intensified by a combined excess of B and P (Chatterjee *et al.*, 1987).

MATERIALS AND METHODS

A field experiment was conducted at CPGSAS, CAU, Umiam , Meghalaya during *kharif* 2019 with four levels of phosphorus (0, 25, 50 , 75 kg ha^{-1}) and four levels of boron (0, 0.5, 1.0, 1.5 kg ha^{-1}) in split plot design with three replications. Geographically, the experiment site was located at $91^{0}18'$ to $92^{0}18'$ E longitude and $25^{0}40'$ to $26^{0}20'$ N latitude with an altitude of 950 m above the mean sea level with Agro-Climatic zone of mixed subtropical hill and falls in AES-III zone (Choudhury *et al.*, 2012). Annual climate of Umiam is divided into three different seasons: pre-monsoon (March to May), monsoon (June to September) and post-monsoon (October to February) months. The temperature of this region varies between 10 - 30^{0}C and precipitation of 2410 mm (Ray *et al.*, 2012). The initial experimental soil is sandy clay loam in texture, pH (4.99), EC (0.42 dSm^{-1}), high in organic carbon (1.32%), low in available nitrogen (251.35 kg ha^{-1}), low in available phosphorus (13.68 kg ha^{-1}), high in available potassium (233.24 kg ha^{-1}), low in available boron (0.054 ppm). The meteorological parameters observed during the crop period are mentioned in Fig.1.

RESULTS AND DISCUSSION

Plant height (cm):

The plant height of black gram observed under different phosphorus and boron combinations is presented in Table.1. It increased with crop development stages i.e. 30 DAS, 60 DAS and at maturity. Increasing phosphorus and boron doses also increased plant height over control at all crop development stages i.e. 30 DAS, 60 DAS and at maturity. At 30 DAS, under different phosphorus doses, the highest plant height (20.48 cm) was recorded at 75 kg P_2O_5 ha^{-1}, however, the significant increase was observed up to 50 kg P_2O_5 ha^{-1} with 20.01 cm height. Similarly, under different boron doses, the highest plant height (20.13 cm) was observed at 1.5 kg B ha^{-1}. The lowest plant height was recorded in control plots of P and B as 15.64 and 16.24 cm, respectively.

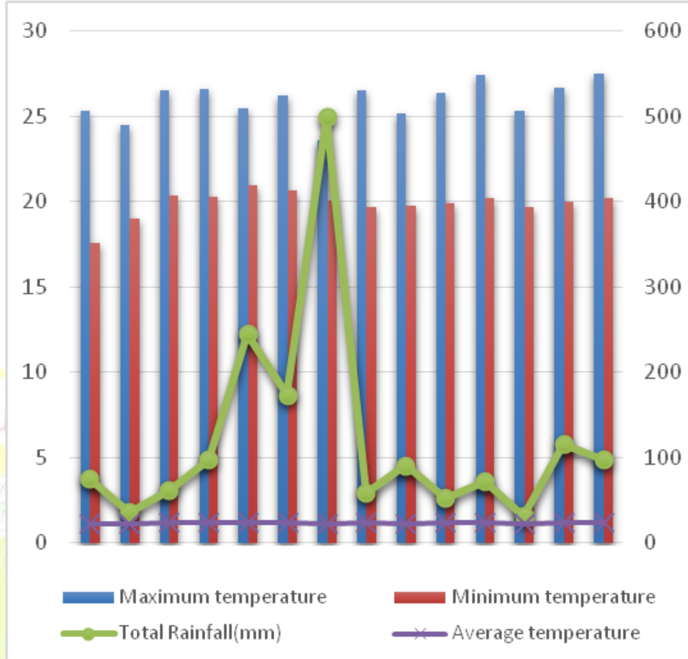

Fig.1 Standard week wise meteorological data during the crop season

The similar trend in plant height of black gram was observed at 60 DAS and at maturity. Under different phosphorus doses, the highest plant height at 60 DAS was recorded at 75 kg P_2O_5 ha^{-1} as 38.44 cm but the significant increase was observed up to 50 kg P_2O_5 ha^{-1} with 37.58 cm height. Similarly, under different boron doses, the highest plant height (37.22 cm) was observed at 1.5 kg B ha^{-1}. Opposing to this, the lowest height of plants was recorded in control plots of P and B as 30.45 and 32.50 cm, respectively. Similar to this, under different phosphorus doses, the highest plant height at maturity was recorded at 75 kg P_2O_5 ha^{-1} as 43.43 cm. Here also, the significant increase was observed up to 50 kg P_2O_5 ha^{-1} with 42.89 cm height. Similarly, the highest plant height (42.60 cm) under different boron doses was observed at 1.5 kg B ha^{-1} whereas, in control plots of P and B, the lowest plant height was recorded as 36.58 and 38.17 cm, respectively at maturity. The increase in plant height by phosphorus might be attributed to enhanced photosynthetic rate thereby encouraging the vegetative growth (El-Habbasha *et al.*, 2007). Similarly, increased plant height of black gram with the application of boron might be due to more cell division and cell elongation resulting in enhanced plant growth and plant height (Camacho-Cristóbal *et al.*, 2015; Satya and Sanjay-Swami, 2020).

Table 1: Effect of phosphorus and boron on plant height (cm) of black gram at 30, 60 DAS and at maturity

	30 DAS					60 DAS					Maturity				
Treatments	B_0	$B_{0.5}$	$B_{1.0}$	$B_{1.5}$	Mean	B_0	$B_{0.5}$	$B_{1.0}$	$B_{1.5}$	Mean	B_0	$B_{0.5}$	$B_{1.0}$	$B_{1.5}$	Mean
P_0	13.213	15.783	16.487	17.103	15.647	27.140	28.993	31.953	33.720	30.452	34.243	35.663	37.000	39.417	36.581
P_{25}	16.387	17.690	18.380	19.123	17.895	32.013	34.057	35.567	35.953	34.398	36.303	38.360	41.637	42.470	39.693
P_{50}	17.447	19.190	21.360	22.037	20.008	34.890	37.247	38.870	39.310	37.579	40.767	43.013	43.763	44.017	42.890
P_{75}	17.907	19.903	21.863	22.263	20.484	35.950	38.367	39.563	39.887	38.442	41.377	43.583	44.270	44.503	43.433
Mean	16.238	18.142	19.523	20.132	18.509	32.498	34.666	36.488	37.218	35.218	38.173	40.155	41.668	42.602	40.649
	SE(m)$\pm$		C.D (p<0.05)			SE(m)$\pm$		C.D (p<0.05)			SE(m)$\pm$		C.D (p<0.05)		
P	0.589		2.037			0.910		3.148			0.887		3.068		
B	0.164		0.478			0.215		0.627			0.288		0.841		
P within B	0.654		2.195			0.983		3.325			1.017		3.388		
P within B	0.328		0.957			0.430		1.255			0.576		1.681		

The interaction effect of phosphorus and boron on plant height was found to be significant at all crop development stages. Within the same level of boron, the plant height increased with the increasing phosphorus doses, but significantly highest plant height at 30 DAS (20.04 cm) and 60 DAS (39.31 cm) was recorded with the application of $P_{50}B_{1.5}$ whereas at maturity, the plant height was recorded maximum (43.01 cm) at $P_{50}B_{0.5}$. Similarly, within the same level of phosphorus, the increasing boron doses increased the plant height of black gram but the significant increase in plant height was recorded at $P_{75}B_1$ as 21.86 cm, $P_{50}B_1$ as 38.87 cm and $P_{75}B_{0.5}$ as 43.58 cm at 30, 60 DAS and at harvesting. The lowest height of black gram was observed in control i.e. P_0B_0 as 13.21 cm, 27.14 cm, 34.24 cm at 30, 60 DAS and at maturity. The similar results were observed by Sentimenla *et al.* (2012) who reported that different levels of phosphorus and boron increased plant height of soybean significantly. The increased plant height of groundnut was also reported with the combined application of P and B over control plots (Kabir *et al.,* 2013). Similar findings in French bean were also reported by Singh *et al.,* (1989).

Number of pods per plant:

The number of pods per plant increases with increasing phosphorus and boron doses and data are presented in Table 2. Among the main plot (phosphorus) treatments, highest number of pods per plant (18.71) was observed at 75 kg P_2O_5 ha^{-1}, however significant increase in number of pods was observed only up to 50 kg P_2O_5 ha^{-1} (17.13). Control plot had recorded lowest number of pods i.e. 12.88 pods per plant. The significant increased number of pods per plant was observed up to 1.5 kg B ha^{-1} as 17.20 and lowest as 14.27 pods per plant in control. The per cent increase of number of pods over control to successive levels of P was 17.10, 33.00, 45.25 per cent and with successive increase in B levels over control was 10.29, 16.30, 20.56, respectively. The interaction effect of phosphorus and boron on number of pods per plant was found to be significant. The lowest number of pods was recorded in control at P_0B_0 with 11.93 pods per plant and significantly highest number of pods was observed at $P_{75}B_1$ as 19.89 at phosphorus within boron and boron within phosphorus. The per cent increase of $P_{75}B_1$ over P_0B_0 was 66.72.

Choudhary *et al.* (2017) reported that numbers of pods $plant^{-1}$ were significantly affected by phosphorus and boron application. Significantly maximum (42.46) number of pods $plant^{-1}$ were obtained by N3 (20:60:20 NPK) + 35 DAS (0.2% foliar spray of borax). The significant minimum (30.40) numbers of pods $plant^{-1}$ were obtained in N1 (20:40:20 NPK). This might be due to boron helps in pollen formation and grain formation. According to Dutta *et al.* (1984), numbers of pods per plant increased with the application of boron. These results are in line with Kaisher *et al.,* (2010); Satya and Sanjay-Swami (2021). Numbers of pods per plant were significantly affected by boron application. Ali *et al*. (2011) reported that boron treatment achieved a significant increase in the number of pods with a percentage increase of 10% compared to control. Moreover, Reddy *et al*. (2007) indicated that application of micronutrients including boron significantly influenced total yield in pigeon pea through the modification of plant growth morphology and physiology. The increase in pod yield observed in this study might be attributed to flower inhibition, pod abscission and improvement in morpho-physiological characteristics such as plant height, number of branches, leaf area, pod yield and increased dry matter accumulation and its portioning to increase pod per plants. Sentimenla *et al.* (2012) reported highest number of pods per plant with application of 1.5 kg B ha^{-1} and interaction effect of P and B on number of pods per plant. Positive influence of P and B application on number of pods per plant was also reported by Sharma (1992), Pradhan *et al.* (1995) in soybean. This might be attributed to significant increase in nodulation, nitrogenase activity, growth and efficient nutrient uptake (Srivastava *et al.,* 1998). Combined application of phosphorus and boron also significantly influenced the number of pods $plant^{-1}$.

Table 2: Effect of phosphorus and boron on number of pods per plant of black gram

Treatments	Number of pods per plant				
	B_0	$B_{0.5}$	$B_{1.0}$	$B_{1.5}$	Mean
P_0	11.93	12.46	13.36	13.78	12.882
P_{25}	13.64	14.73	15.54	16.43	15.084
P_{50}	15.56	17.03	17.60	18.34	17.133
P_{75}	15.95	18.74	19.89	20.26	18.710
Mean	14.270	15.738	16.597	17.203	15.952

	SE(m)±	C.D (p≤0.05)
P	0.540	1.870
B	0.169	0.493
P within B	0.615	2.051
B within P	0.338	0.987

Seed yield (q ha^{-1})

The data pertaining to seed yield of black gram is presented in Fig 2. The seed yield increased with increasing phosphorus and boron doses. The highest seed yield (9.52 q ha^{-1}) among different phosphorus doses was observed at 75 kg P_2O_5 ha^{-1}. However, seed yield increased significantly up to 50 kg P_2O_5 ha^{-1} with 9.52 q ha^{-1}. The lowest seed yield was recorded in control plots as 6.41 q ha^{-1}. With successive boron doses, the lowest seed yield was obtained at control (7.19 q ha^{-1}), although significant increased seed yield was observed up to 1.0 kg B ha^{-1} as 9.13 q ha^{-1} yet the highest seed yield was recorded as 9.43 q ha^{-1} at 1.5 kg B ha^{-1}. The phosphorus and boron interaction on seed yield was also found significant. The lowest seed yield were observed in control at P_0B_0 as 5.56 q ha^{-1} and significantly highest seed yield was observed at $P_{50}B_{1.5}$ as 10.35 q ha^{-1} at phosphorus within boron and in boron within phosphorus as 11.03 q ha^{-1} at $P_{75}B_1$. The increase in seed yield with the increasing phosphorus application might be due to improvement in plant growth and vigour as phosphorus plays important role in plant metabolism finally leading to enhanced seed yield. The improvement in dry matter yield can be attributed to the role of boron in stabilizing certain constituents of cell wall and plasma membrane, enhancement of cell division and tissue differentiation, metabolism of carbohydrates, proteins, nucleic acids, auxins and phenols (Marschner 1986). Kamboj and Malik (2018) reported that increase in phosphorus and boron doses increases the seed yield of black gram with highest yield recorded on combined application of 100 mg P kg^{-1} along with 1.0 mg B kg^{-1} in green gram. Higher grain yield of mungbean (1583 kg ha^{-1}) was also reported by Subedi and Yadav (2013). Similarly, Chowdhury *et al.*, (2015) reported that interaction effect of P and B significantly influenced the quality attributes of lettuce seeds and also found that application of 120 kg P_2O_5 kg ha^{-1} and 2 kg B ha^{-1} was better combination for better growth, yield and quality of lettuce.

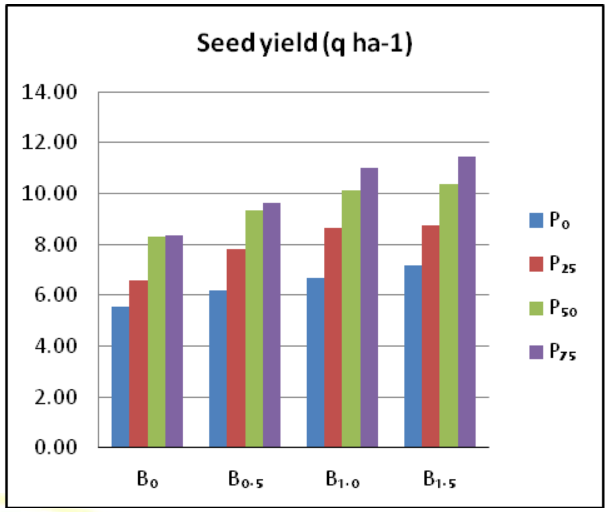

Fig. 2: Effect of phosphorus and boron on seed yield of black gram

Seed index:

The Fig. 3 illustrates that the individual effect of phosphorus on seed index of black gram was highest (4.40) at 75 kg P_2O_5 ha^{-1} which was statistically at par with 50 kg P_2O_5 ha^{-1} with seed index value 4.12, lowest was observed at control (3.14). Likewise, 1.5 kg B ha^{-1} has recorded significantly highest seed index (4.22) and lowest (3.34) was observed in control plot treatment. The per cent increase in seed index in successive levels of P over control was 16.78, 31.19, 40.00 per cent and in successive levels of boron over control was 11.61, 20.66, 26.26, respectively. The interaction effect of phosphorus and boron on seed index was found to be significant. Significantly lowest seed index were observed in control at P_0B_0 as 2.54 and significantly highest seed index were observed at $P_{50}B_{1.5}$ as 4.64 at phosphorus within boron and in boron within phosphorus the significantly highest value was observed at $P_{75}B_1$ as 4.58. The percentage increase of $P_{50}B_{1.5}$, $P_{75}B_1$ over P_0B_0 was 82.80 and 80.44 percent, respectively.

Mouri *et al.* (2018) reported that the effect of phosphorus on weight of 100-seeds was significant. Weight of 100-seeds was the highest (43.31g) in 60 kg P ha^{-1} followed by 40, 20 and 0 kg P ha^{-1}, respectively. This finding is in agreement with El-Habbasha *et al.* (2005). He reported that increasing phosphorus levels increased 100-seeds weight. Timotiwu *et al.* (2018) reported that fertilization of P_2O_5 with dose of 0 kg/ha, weight of 100 grain produced was 11.27 g and increased as 0.005 g of every additional 1 kg of P_2O_5. This is in parallel with research of Thoyyibah *et al.* (2014) who stated that application of various doses of phosphate fertilizers in two soybean varieties had significant effect on grain weight per plant, Detam-1 variety which was cultivated 200 kg/ha of phosphate fertilizers produced the highest weight 42.02 g,

equivalent to 3.5 ton/ha and had great significance with other combinations. Soybean plants with the application of 5 ppm B increased weight 100 grain 6.41% higher than those without B. The research of Bellaloui *et al.* (2013) also showed that application of B through the leaves can increase the seed weight of 16.1 g (100 grain weight) higher than that obtained without B of 13.2 g of soybean on treatment given water. This is in line with Rio Tinto (2012) who stated that the addition of boron in plants could increase the success of flower pollination and played a vital role in seed formation. He further stated that application of boron on soybean increased the weight of 100 grains.

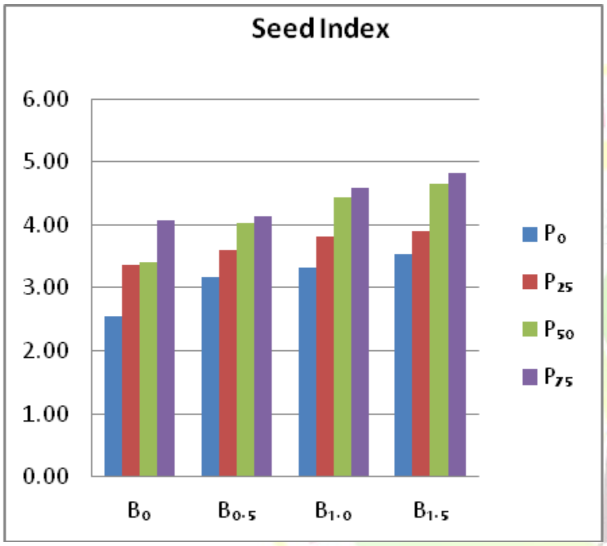

Fig. 3: Effect of phosphorus and boron on seed index of black gram

CONCLUSION

The results of the above experiment suggested that highest seed yield was found when 50 kg P_2O_5 ha^{-1} along with 1.5 kg B ha^{-1}. Significant plant height at 30 DAS (20.04 cm) and 60 DAS (39.31 cm) was found with the application of $P_{50}B_{1.5}$ whereas at maturity, the plant height was recorded maximum (43.01 cm) at $P_{50}B_{0.5}$, 75 kg P_2O_5 ha^{-1} and 1 kg B ha^{-1} had significant effect on number of pods per plant, where as 50 kg P_2O_5 ha^{-1} and 0.5 kg B ha^{-1} has significant effect on seed index of black gram plant.

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Research Article

Participatory analysis and evaluation of IPM practices against sucking pests of *Bt* cotton

Shakti Khajuria*, A.K.Rai, B.S. Khadda, Raj Kumar and K. Lata
ICAR-Krishi Vigyan Kendra- Panchmahals, Godhra-Vadodara Highway Vejalpur, Panchmahals, Gujarat, India
**Corresponding author e-mail: shaktikhajuria@gmail.com*
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ABSTRACT
Farmer's participatory demonstrations were evaluated during *kharif* seasons of 2017-2018 and 2018-2019 at four villages of Panchmahal district, Gujarat to introduce IPM practice and to evaluate their effectiveness through demonstrations. Farmers identified several constraints of which, increased infestation of sucking insect pests *viz*., aphid (*Aphis gossypii* Glover), leaf hopper (*Amrasca biguttula biguttula* Ishida) and whitefly (*Bemisia tabaci* Gennadius) were the most important. IPM practice consisting of one spray application of *Beauveria bassiana* (2 x 10^8cfu) @ 4 g /l water, two spray applications of thiamethoxam 25 WG @ 0.01 per cent (0.4 g /l water) and one spray application of acephate 75 SP @ 0.075 per cent (1 g /l water) following threshold level (5 sucking pests /leaf) was found effective and economical for the management of sucking insect pests without any adverse effect on the natural enemies in *Bt* cotton. The application of this practice also resulted higher seed cotton yield as compared to farmers practice.
Keywords: *Bt* cotton, IPM practices, natural enemies, sucking insect pests.

INTRODUCTION
Cotton (*Gossypium spp.*) is a fiber crop. It is popularly called as friendly fiber because of its versatility, appearance, performance and above all its natural comfort. Cotton pest management has always been an immensely challenging task for entomologists all over the world. About 1326 species of insects have been reported on cotton worldwide. In India around 162 insect pests have been reported to cause damage to the cotton crop (Dhaliwal and Arora, 1998). Among them, only a dozen are major and half of them are key production constraints which cause losses to the extent of 30-80 per cent. Cotton is an excellent reproductive host for many sucking insects such as leafhoppers, *Amrasca devastans* (Distant); aphids, *Aphis gossypii* (Glover) and whiteflies, *Bemisia tabaci* (Gennadius). The avoidable loss due to sucking pests is up to 33.02 % (Nikam *et al.* 2017). Cotton growers depend heavily on synthetic pesticides to combat sucking pests. At least 2-3 sprays are directed against sucking pests. Due to Continuous and indiscriminate use of synthetic insecticides, there is resistance and hence increase in production cost, toxicity to natural enemies. So, potential solution is adoption of IPM strategies plays a key role. Keeping these things in view participatory analysis and evaluation of IPM practices was demonstrated in farmer's fields for the management of sucking pest in *Bt* cotton.

MATERIALS AND METHODS
The field demonstrations were carried out during *Kharif* season of 2017-2018 and 2018-2019 at four villages of Panchmahal district to evaluate the IPM practices against sucking pests of *Bt* cotton under FLD activity of ICAR- Krishi Vigyan Kendra-Panchmahal (Gujarat). In this study, 12 farmers were selected for demonstration. The IPM technology was adopted from AAU, Anand (Gujarat) while farmers' practice comprised of chemical insecticide sprays (Table1). The insecticides were sprayed when the pest attained Economic Threshold Level (ETL). The observations on population of sucking insect pests' *viz*., aphid, leaf hopper and whitefly were made on three plants selected randomly in each sector. From each selected plant, three leaves were selected randomly from top, middle and bottom canopy to record the pest population. The observations were recorded at fortnightly interval right from the germination to last picking of the crop. Cotton yield was recorded and the data were presented as seed

cotton yield in q/ha and benefit cost ratio was also worked out.

Table 1. Details of management practice against sucking pests of cotton

Management practice	Details
Integrated Pest Management Practice (IPM)	IPM practices consisting of ; One need based (5 aphids or leafhoppers or whiteflies/leaf) application of *Beauveria bassiana* (2 x 10^8 cfu/g) @ 4 g/l water followed by two need based applications of thiamethoxam 25 WG 0.01% (0.4 g/l water) (50 g a.i./ha). Need based (5 thrips/ leaf) application of acephate 75 SP 0.075% (1 g/l water) (375 g a.i./ha). The waiting period of thiamethoxam 25 WG 0.01% (50 g a.i./ha) and acephate 75 SP 0.075% (375 g a.i./ha) maintained 21 and 15 days after application, respectively.
Farmer's Practice	Farmers used unsystematic spraying of different insecticides like imidacloprid 17.8 SL @ 200 ml/ha, fipronil 5% SC @ 1500 ml/ha, monocrotophos 36% SL @ 800 ml /ha etc. at different crop stages. The farmers usually tend to give higher than the recommended dose

Statistical analysis

The data collected were transformed into square root values as per the standard requisites. The experiments were subjected to statistical scrutiny following the method of Panse and Sukhatme (1989) and the means were compared with Least Significant Difference (L.S.D.).

RESULTS AND DISCUSSION

A comparison of frontline demonstrations based on IPM practices (recommended technology) and farmer's practices were analyzed as presented in Table 2. Of the two practices, IPM practice (recommended technology) for the management of sucking pests in *Bt* cotton was found to be more effective over farmer's practice. During 2017-18, IPM practice revealed lower mean infestation of aphids (0.92/3 leaves), leafhoppers (0.54/3 leaves) and whiteflies (0.20/3 leaves) Farmer's practice showed higher mean infestation of aphids (15.37/3 leaves), leafhoppers (5.10/3 leaves) and whiteflies (3.02/3 leaves). Highest yield of 27.63 q/ha was recorded in IPM practice as compared to farmer's practice (20.50 q/ha) resulting higher C:B ratio of 1:2.60 in IPM practice. During 2018-19 at all the locations of demonstrations, mean aphids, leafhoppers and whiteflies were observed lower in IPM practice as compared to higher in farmer practice. The lower infestation of aphids, leafhoppers and whiteflies in IPM demonstrations were (1.90, 0.60 & 0.27/3 leaves) as compared to farmer practice (14.20, 4.16 & 2.70/3 leaves) respectively, where it was significantly higher. Highest yield of 25.70 q/ha was recorded in IPM practice whereas 18.50 q/ha were recorded in farmers practice. The Cost: Benefit ratio was also high in the IPM practice 1:2.45 as compared to farmer's practice (1:1.94).

The data over two years 2017-18 and 2018-19 of demonstration (Table 2) indicated that IPM practice (recommended technology) was better than the farmer's practice under local conditions.

Table 2. Impact of IPM practices against sucking pests of *Bt* cotton

	Aphids		Leafhoppers		Whiteflies		Yield (q/ ha)		Cost: Benefit ratio	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
IPM Practice	0.92 (1.40)	1.90 (1.69)	0.54 (1.25)	0.60 (1.27)	0.20 (1.10)	0.27 (1.13)	27.63	25.70	2.60	2.45
Farmer Practice	15.37 (4.07)	14.20 (3.88)	5.10 (2.45)	4.16 (2.24)	3.02 (2.10)	2.70 (1.94)	20.50	18.50	2.00	1.94
S.E±	(0.03)	(0.06)	(0.04)	(0.91)	(0.80)	(0.61)				
CV	(3.71)	(4.62)	(3.13)	(5.93)	(6.74)	(5.21)				
LSD (5%)	(0.08)*	(0.12)*	(1.06)*	(2.02)*	(2.40)*	(1.37)*				

Figures in parenthesis are transformed values of $\sqrt{x+1}$ * Significant at 5%

Thus, IPM strategy kept the population of sucking insect pests *viz*., aphid, leaf hopper and whitefly below their threshold level (5/leaf). Khajuria *et al.*, (2017) reported that *Beauveria bassiana* reduced the infestation of aphids on potato crop. Srinivasan *et al.*, (2004) have reported higher effectiveness of thiamethoxam for the control of sucking pests in cotton. Bharpoda *et al.* (2016) also reported that IPM module, fungal bio-agent and thiamethoxam were successful in managing the cotton pests. During present study also, *Beauveria bassiana*, a fungal bio-agent and thiamethoxam, a neonicotinoid are also found effective in management of sucking pests in cotton. Birah *et al.*, (2019) and Khajuria *et al.*, (2016) have reported that the seed cotton yield from IPM plots was high which resulted in a higher cost benefit ratio in comparison with farmer's practice. These results are in accordance with our study as in the present study highest yield was obtained in IPM during both the years of investigation. Over all, the benefit cost ratio was high in IPM as compared to farmers' practice.

CONCLUSION

IPM practices were found effective in comparison to farmer practice of indiscriminate use of pesticides. The results clearly indicated that integrated pest management strategies needs to be adopted even in *Bt* cotton to have higher yield and better benefit cost ratios. So, the above said management practices must be followed by the cotton growing farmers. It is concluded that IPM strategy can be recommended to the farmers for management of sucking pests effectively and economically in cotton.

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Research Article

Impact of Krishi Vigyan Kendra on transferring knowledge to tribal farmers on improved animal husbandry practices

B.S.Khadda*, Kanak Lata, Raj Kumar, S. Khajuria and A. K. Rai
ICAR-Krishi Vigyan Kendra- Panchmahals, Godhra-Vadodara Highway Vejalpur, Panchmahals, Gujarat, India
**Corresponding author e-mail: khadda74@gmail.com*
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ABSTRACT

A study was conducted on the impact of KVK interventions on transferring knowledge to tribal farmers on improved animal husbandry practices in Panchmahal district of central Gujarat, to creating awareness regarding the efficient technologies through various efficient extension tools under the banner of ICAR- KVK, Panchmahal. A random sampling technique was applied to draw the samples of 120 farmers from eight villages of Kalol and Jambughoda Tehsil of Panchmahal district. Accordingly, strategies of technological intervention were made regularly during the period of study. In adopted villages, KVK, Panchmahal organized several activities like animal health camps, training programs, advisory services, and FLDs on different aspects of animal husbandry. The results of the study revealed that the means knowledge index and mean adoption index were recorded 39.24 and 93.81 and 77.24 and 25.43 percent, respectively for pre and after interventions. The impact of KVK interventions was found to be 53.19 percent over the existing knowledge and adoption by the trained farmers which were found to be substantial over the non-benefited tribal farmers on various aspects of animal husbandry after the intervention of Krishi Vigyan Kendra, Panchmahal. Based on the study it may be concluded that the overall improvement in the knowledge of the tribal farmers with respect to the adoption of animal husbandry technologies would be possible through the demonstration of efficient technologies needed for healthy livestock rearing which had not only created awareness but also improved the knowledge and attitude of tribal farmers in relation to scientific animal husbandry practices.
Keywords: *Adoption, Animal Husbandry, Improved, KVK, Training, Knowledge.*

INTRODUCTION

To ameliorate the poor socio-economic conditions of the farmers by raising the level of farm productivity, income, and employment with the application of agricultural innovation generated at the research station, an innovative extension education institution i.e. Krishi Vigyan Kendra (KVKs) was introduced by the ICAR (Dubey et al., 2008). Krishi Vigyan Kendra (KVK) is an innovative science-based institution which functions on the collaborative participation of scientist, subject matter experts, extension functionaries, and farmers. The main purpose of KVK is to impart learning through work experience to those who are engaged in farming. The progress in any field depends to a large extent on the quick and effective dissemination of new technologies among the beneficiaries and bring back their problems to the research labs for their solution. Knowledge may be defined as those behavior and test situations, which emphasize upon memorization the remembering, either by recognition or recall of ideas. One of the main mandates of Krishi Vigyan Kendra is to provide and improve the level of knowledge of the trainees about the improved farm technologies (Gupta and Verma, 2013) because knowledge is a cognitive component of an individual's mind and plays an important role in covert as well as overt behavior. Therefore the individuals with a greater technical knowledge of improved practices would lead to a high adoption possibly because knowledge is not inert. Once knowledge is acquired and retained, it undergoes and produces changes in the thinking process and of mental alchemy. This study was, therefore, conducted to ascertain the impact of animal husbandry technologies among tribal farmers as well as their prevailing level of awareness knowledge of animal husbandry technologies.

MATERIALS AND METHODS

The study was conducted under the banner of ICAR-KVK, Panchmahal. The accessible population for this descriptive study was one hundred twenty respondents. Random sampling technique was applied to draw the samples of 120 farmers from eight villages of Kalol and Jambughoda Tehsil of Panchmahal district during 2020. The data were collected through personal interview method using structural schedule. The bench mark survey data of the KVK was used as the baseline for the existing knowledge score of the farmer while the degree of impact of KVK in terms of gain in knowledge of farmers was measured with the help of schedule developed for the study purpose. Accordingly strategies of technological intervention were made regularly during the period of study. In adopted villages, KVK, Panchmahal organized several activities like as animal health camps, training programmes, advisory services and FLDs on different aspects of animal husbandry. The technological interventions were proposed to assess, refine and improve the productivity of livestock in terms of milk, meat etc. and health management. To collect the data, the respondents were individually interviewed by the investigator herself after making good rapport with them. The information regarding knowledge were recorded on scale point of fully knowledge, considerable knowledge, least knowledge and not knowledge were analyzed with score value of 3, 2, 1 and 0 respectively and in case of adoption rate was calculated with the scale point of fully adopted, partially adopted, ready to adopted and not adopted were analyzed with score value of 3, 2, 1 and 0 respectively. The collected data were subjected to basic statistical analysis as per Snedecor and Cochran (1994). The impact index was worked out with the help of following formula:-

$$\text{Impact Index} = \frac{[\text{MKI of after interventions} - \text{MKI of pre interventions}]\ [\text{MAI of after interventions} - \text{MAI pre interventions}]}{2}$$

*MKI - Mean Knowledge Index and
*MAI - Mean Adoption Index

RESULTS AND DISCUSSION

The tribal farmers have the affinity for animal component and traditional habit of rearing dairy animals like cow, buffalo, goat and also some poultry birds in backyard system. The results of the study revealed that the before and after intervention of technologies *viz.* Animal health camp, training programme, advisory service and FLDs influenced the knowledge of tribal farmers towards the knowledge and adoption of recommended improved animal husbandry production technologies.

Table 1. Knowledge and adoption indices of improved animal husbandry practices (N=120)

Improved animal husbandry practices	Knowledge Index (%)		Adoption Index (%)	
	Pre-intervention	After intervention	Pre-intervention	After intervention
Breeds and selection criteria	41.67	83.67	25.33	55.67
Up gradation of local breeds	45.67	100.00	40.00	100
Heat detection	40.67	100.00	35.67	100
Housing and general management	40.00	92.33	10.33	55.33
Balance ration feeding	32.67	93.67	17.67	56.00
Mineral mixture feeding	25.33	100.00	15.33	85.33
Common salt feeding	36.67	100.00	22.33	89.00
Formulation and preparation of balance ration	28.67	85.33	10.00	43.67
Kid/ calf rearing	52.67	85.67	37.00	74.67
Treatment of repeat breeder	45.67	93.33	26.00	85.67
Vaccination	40.67	96.33	32.33	93.67
Deworming	40.33	100.00	31.33	92.67
Green fodder production round the year	52.67	86.67	33.00	70.00
Clean and quality milk production	26.00	96.33	19.67	79.67
Mean Index	39.24	93.81	25.43	77.24

Table 2. Impact of KVK on transferring knowledge and adoption of improved animal husbandry practices (N=120)

Particulars	Pre-intervention	After intervention	Difference
Mean Knowledge Index	39.24	93.81	54.57
Mean Adoption Index	25.43	77.24	51.81
Total	64.67	171.05	106.38

$$\text{Percentage of Impact} = \frac{\textbf{Sum of differences of indices}}{\textbf{2}} = 53.19$$

Knowledge level of respondents:

Analysis of data revealed that the average means knowledge index pre and after interventions was recorded 39.24 and 93.81 per cent, respectively. The data of the study revealed that the tribal farmers of the study area had very less knowledge about scientific animal husbandry practices before intervention (Table

1). The results of study revealed that the all farmers had knowledge on the varies improved animal husbandry practices namely, up gradation of local breeds, heat detection, mineral mixture feeding, common salt feeding and deworming of their animal, whereas the corresponding knowledge level for the same practices for the farmers before intervention of KVK, Panchmahal were 45.67, 40.67, 25.33, 36.67 and 40.33 per cent, respectively. The overall 139.07 % increase in the knowledge on various aspects of improved animal husbandry practices after intervention of Krishi Vigyan Kendra, Panchmahal. More or less similar results were also reported by Khadda *et al.* (2012), Gupta and Verma (2013), Singh *et al.* (2014), Narayan (2015) Khadda *et al.* (2015) and Soumya and Podikunju (2016).

Adoption level of respondents regarding improved animal husbandry practices:

The results of present study revealed that the mean adoption index was found to be greater (77.24 %) for the benefited farmers after intervention of KVK, Panchmahal as compared to the same farmers before interventions (25.43 per cent). The tribal farmers had adopted the improved animal husbandry practices namely up gradation of local breeds, heat detection(100 %) followed by vaccination (93.67 %), deworming (92.67 %), common salt feeding (89.00 %), treatment of repeat breeder (85.67 %), mineral mixture feeding (85.33 %), clean and quality milk production (79.69 %), kid/ calf rearing (74.67 %), green fodder production round the year (70.00 %), balance ration feeding (56.00 %), breeds and selection criteria (55.67%), housing and general management (55.33%) and formulation and preparation of balance ration (43.67%). More or less similar results were also reported by Gupta and Verma (2013), Singh *et al.* (2014), Narayan (2015) Khadda *et al.* (2015) and Soumya and Podikunju (2016).

Impact on knowledge and adoption regarding improved animal husbandry practices:

The impact of interventions imparted by the KVK as a whole was computed as the sum total of the differences of both the indices namely, Mean Knowledge Index (MKI) and Mean Adoption Index (MAI) divided by two. The data related to impact on knowledge and adoptions regarding improved animal husbandry practices have been presented in table 2. The data presented in table 2 exposed that the mean knowledge index and mean adoption index were found to be 93.81 and 77.24 per cent, respectively for the trained farmers after interventions, whereas for the same farmers before interventions the mean knowledge index and mean adoption index was found to be 39.24 and 25.43 per cent, respectively. It clearly showed that the trained farmers had greater knowledge and adoption levels compared to the non-trained farmers. The study also observed that the impact of KVK interventions was found to be 53.19 per cent over the existing knowledge and adoption by the trained farmers which were found to be substantial over the non-benefited tribal farmers. The similar results were also reported Soumya and Podikunju (2016). Therefore it could be confirmed that there was a remarkable impact of KVK, Panchmahal on those respondents who attended/ benefited through different programmes conducted with special references to of knowledge and adoption of improved animal husbandry practices. The respondents need to be further expected through training programme, animal health camp, advisory service, diagnostic visit, FLDs, etc. to equip sufficiently with knowledge and skill enabling to adopt the recommended practices for better income.

CONCLUSION

Based on the study it may be concluded that the overall improvement in the knowledge of the tribal farmers with respect to adoption of animal husbandry technologies would be possible through the demonstration of efficient technologies needed for healthy livestock rearing which had not only created awareness but also improved the knowledge and attitude of tribal farmers in relation to scientific animal husbandry practices. The knowledge regarding the available viable animal husbandry is essentially required to improve the productivity of livestock as well as socio-economic condition of the resource poor tribal farmers.

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